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A Summary of Current Program 7/1/67

JP 2

and Preliminary Report of Progress  
for 7/1/66 to 6/30/67

TRANSPORTATION AND FACILITIES

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AGRICULTURAL RESEARCH SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE

This progress report is primarily a tool for use of scientists and administrators in program coordination, development, and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

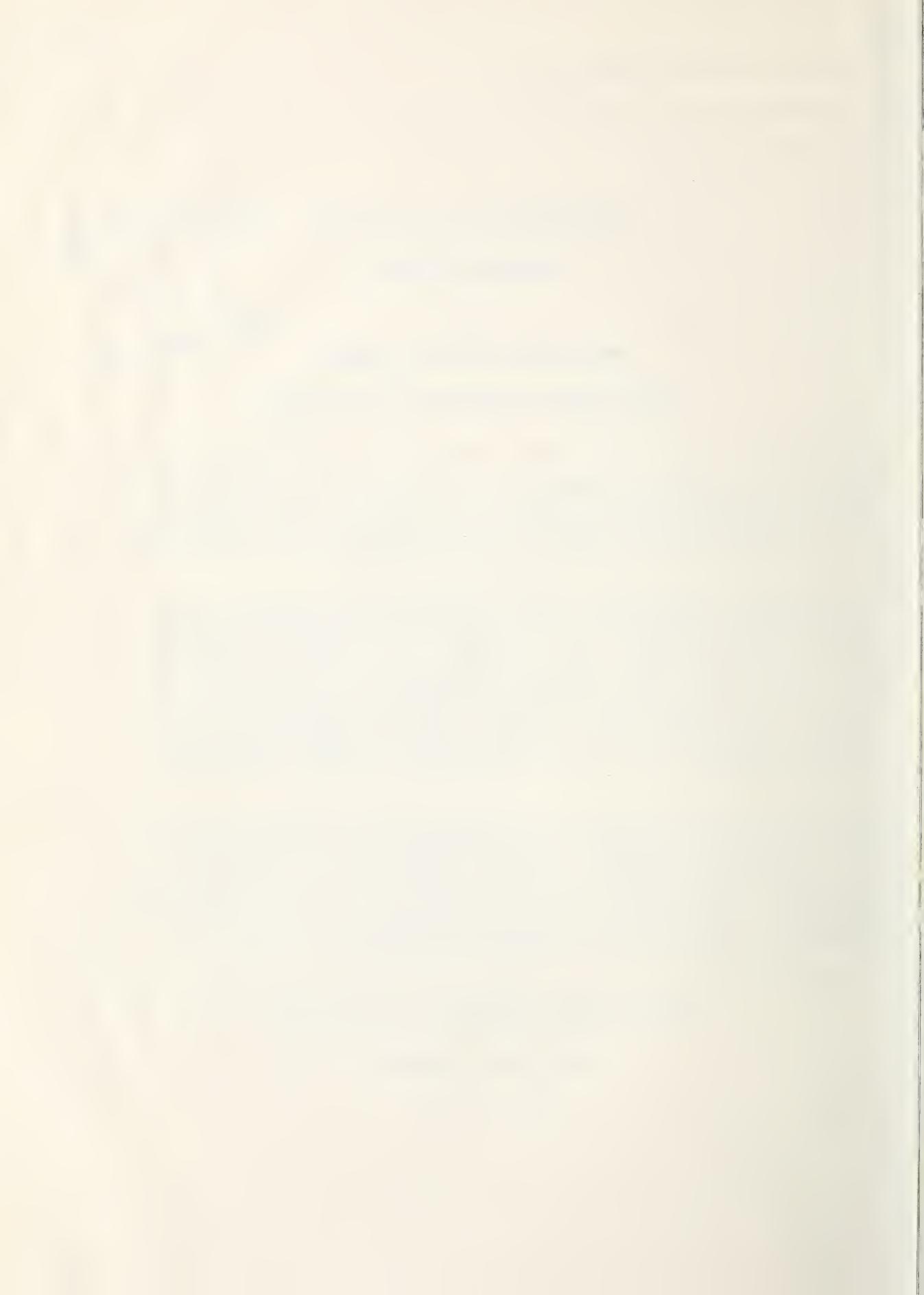
The summaries of progress on USDA and cooperative research include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed, will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members and others having a special interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of USDA and cooperative research issued between July 1, 1966, and June 30, 1967. Current agricultural research findings are also published in the monthly USDA publications, Agricultural Research and Agricultural Marketing. This progress report was compiled in the Transportation and Facilities Research Division, Agricultural Research Service, U. S. Department of Agriculture, Hyattsville, Maryland.

UNITED STATES DEPARTMENT OF AGRICULTURE

Hyattsville, Maryland

July 1, 1967



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## INTRODUCTION

Transportation and marketing facilities research of ARS as used in this report is concerned with the structures, equipment, containers, devices, work methods, and operating methods used in marketing and transporting farm and food products from the farms to consumers. It seeks to find ways to improve these physical elements and handling methods in order to increase their efficiency and effectiveness in performing the numerous operations involved, increase labor productivity, and help hold down marketing costs. The research deals largely with the application of engineering-economic and marketing principles. The functions to which these physical elements, handling methods, and labor relate include essentially all marketing operations, especially those directly applicable to the commodities in the physical sense, such as assembling, preparing for market, processing, packaging, precooling, loading, transporting, unloading, storing, warehousing, and wholesale and retail distribution.

The bill for marketing food products to domestic civilian consumers amounted to \$55.3 billion in 1966, an increase of 6 percent over 1965. Rising marketing costs per unit of product accounted for most of the increase, and growth in volume of products for the remainder. Hourly earnings of labor engaged in marketing farm food products averaged 39 percent higher in 1966 than in 1957-59, but improvements in productivity held the increase in labor cost per unit of product to 14 percent. If the full increase in the cost of labor since 1950 had been reflected in higher marketing costs, the total annual marketing bill would be \$10 billion higher than presently. Such marketing and production efficiencies have resulted in the worker with average income spending only 18 percent of his income for food. Seventy-five percent of the total food marketing bill is directly affected by research in the areas covered by this report.

Most of the research by industry differs substantially from that done by public agencies. It relates primarily to the development of products or services which the individual firms offer for sale and is profit oriented. Some of the research and developmental work of industry involves adaptation of research findings of public agencies. Most of the research findings are trade secrets and therefore not made public. Thus, research contributions to public knowledge in this field must come mainly from public-supported research. Such research has special significance to the small firms that cannot afford to do their own research.

Industry contributes to USDA research in numerous ways, particularly in permitting the free use of its facilities, equipment, materials, and supplies in numerous research experiments and tests. Also in some cases industry groups have made cash contributions to help finance USDA research in this field. Research by USDA frequently serves as a catalyst or stimulus to industry research. Indicative of the research results being obtained and the extent of their application by industry are the following examples:

Marketing Facilities in Cities. In Chicago a non-profit organization plans to construct the new wholesale food distribution center recommended in the Division's report published in March 1967. These facilities will occupy 640 acres, and the planners estimate their cost at \$225 million. Annual net savings in food marketing costs should be \$20 million. New facilities for the New York wholesale fresh fruit and vegetable industry were occupied in March. Through these new facilities more than 1/4 billion dollars worth of fruits and vegetables will be distributed annually. Six weeks after the Division's recommendations for Baltimore were published, legislation was enacted by the State of Maryland creating a Regional Market Authority and authorizing the issuance of \$10 million in bonds to pay a part of the cost of carrying out the recommendations. Construction is underway on new facilities recommended for Boston, Springfield, and Pittsburgh; and new studies were begun in Cincinnati, Denver, Salt Lake City, and Oakland.

Marketing Facilities in Producing Areas. In cooperation with State agencies, plans were developed during fiscal year 1967 for 32 marketing facilities of various kinds in producing areas. A new wholesale fruit market in Benton Harbor, Michigan, began operations in June. A study of a poultry plant processing 15 million birds per year has been completed in cooperation with the North Carolina Department of Agriculture. Annual benefits, estimated at \$225,000 per year, will be derived from improved methods and reduced downgrades through the adoption of quality control procedures. In developing improved dairy processing plants in Maryland, Maine, New York, Tennessee, and Indiana savings of more than \$400,000 in operating costs can be realized. A new \$250,000 livestock auction, planned by ARS, has been constructed and put into operation at the Denver Union Stock Yards. As a result the total number of acres required for livestock marketing was reduced from 114 to 37. The City of Denver is considering the released land as a site for a new wholesale food distribution center. In Kansas City, Missouri, a wool marketing cooperative that handles 3 million pounds of grease wool annually anticipates a 50 percent saving in annual operating costs as a result of adopting improvements recommended by ARS.

Hydrohandling System for Apples. It is estimated that roughly 25 percent of the orchard run lots of apples going into storage each fall will not pay storage costs when the fruit is packed out. The problem has become more critical as storage costs have increased and experienced labor who can harvest fruit on a selective basis has decreased. To meet this problem a prototype hydrohandling system for prestorage sorting and sizing of apples has been designed, constructed, and tested during one season under commercial operating conditions. It is designed to eliminate from the total harvest that fruit which should not be stored and then separate the storable fruit into predetermined size classes.

Assuming a 30 percent removal of fruit from orchard run lots, 75 cents per bushel storage charge, and a charge of 10 cents per bushel to run all fruit through the system, the potential saving to the apple industry based on a 25 percent adoption (for an average crop of 130 million bushels) would total \$4 million annually. Millions of consumers, thousands of growers, and several thousand storage and packinghouse firms stand to benefit from this development.

A Two-Fan Crossflow Aeration System for Stored Grain. A new 2-fan crossflow aeration system developed for upright grain storages supplies airflow rates 5 to 10 times higher than conventional systems having the same horsepower. At least 25 percent of the reported 20,000 country and terminal elevators should be able to use this system in one or more of their storage bins to reduce marketing costs. Interest in this system is evidenced by the 3,000 requests received since a report was published three months ago. A saving of but 1/2 to 1 cent per bushel in operating costs and spoilage losses of corn and wheat now requiring drying would amount to an annual saving of 10 to 20 million dollars to producers and consumers.

Computer System for Processing Sales and Accounting Data on Livestock Auction Markets. A computer system for processing sales and accounting data on livestock auction markets has been developed under a research cooperative agreement with the Computer Research Center, University of Missouri. The computer has been programmed and laboratory tested and the complete experimental system installed on the Central Missouri Auction Market, Mexico, Mo.

The computer system minimizes the possibility of errors in computations and preparation of records and accounts, speeds up payment for animals following their sale, provides accurate permanent records of all business transacted and could easily be programmed to handle routine accounting tasks such as payrolls. By leasing computer time to or from other firms in their respective localities, the system could be used economically on most of the 1,725 auction markets in the U. S. It is estimated that the system could reduce the clerical labor needed by 50 percent, resulting in a net savings to the livestock marketing industry of an estimated \$3 million annually.

Palletization and Bin Boxes Reduce Costs of Shipping Apples to Overseas Markets. Putting apple boxes on pallets and handling them as one unit instead of handling each individually can reduce the cost of shipping 100 pounds of apples to Europe by \$1.00. Packing, handling and shipping apples in 800-pound bin boxes instead of 42-pound boxes reduces costs even more-- \$2.58 per hundred pounds of apples shipped to Europe. Moreover, fruit pilfered was only one-tenth of that pilfered from shipments of individual apple boxes. If three-fourths of exported U. S. apples were shipped in 42-pound boxes on pallets and one-fourth of the apples were shipped in 800-pound bin boxes, marketing costs would be reduced approximately \$3 million per year.

Polystyrene Foam Boxes Reduce the Cost of Marketing Fresh Dressed Poultry.

Use of polystyrene foam boxes instead of wood wirebound boxes can reduce the cost of marketing fresh dressed ice-packed poultry. Based on a truck operating cost of 36 cents per mile and a U. S. average shipping distance of 500 miles per truck shipment, it costs 65.9 cents per 100 pounds to ship ice-packed poultry in wirebound boxes and 56.5 cents per 100 pounds to ship ice-packed poultry in polystyrene foam boxes. Since about 5,179 million pounds of U. S. poultry per year are shipped in wirebound boxes the potential savings if polystyrene boxes were to be used amount to \$4.9 million per year. In addition, laboratory tests indicate that poultry carcass weight loss and microbial breast skin counts are significantly less for poultry packed in polystyrene boxes than in wirebound crates.

Rating Method for Refrigerated Truck Bodies. A method of rating the thermal efficiency of truck bodies used to transport perishable products which measures the amount of heat entering the cargo area will be adopted by truck body manufacturers and users. The industry plans to make the rating method a standard to be applied at approved test stations throughout the country. Its use is expected to help to significantly improve the performance of refrigerated trucks used to transport and distribute frozen foods and other perishable products.

Heavier Loading Reduces Watermelon Shipping Costs. Higher stacking of watermelons for rail shipment can reduce transport costs by about \$200,000 a year for melons shipped from southeastern producing areas to northern markets. Increasing the height of the load in rail refrigerator cars from the customary 5 to 7 layers also would reduce the cost of materials used to cushion the loads by about \$7,000 a year.

Reducing Costs of Distributing Food Through Public Eating Places. About \$28 billion per year is spent for food away from home--roughly one-fourth of total consumer food expenditures, and the percentage is increasing. This food reaches the consumer through about 500,000 restaurants and cafeterias, which in turn are supplied by institutional wholesalers, most of whom are small independent businessmen. The margins of both the institutional distributors and the eating places are high because of their high operating cost. Institutional Distributors. One reason for the high operating cost of distributors is that the average food service operator (restaurant) buys from 18 wholesalers, which results in many small orders. Consolidating these small orders can bring great savings in handling costs, without hurting either the distributor or the food service operator. A publication showing some ways to reduce costs of servicing institutional food orders was prepared and 7,000 copies distributed. Cafeterias. A study of labor utilization and operating practices in commercial cafeterias showed that labor costs averaged 32 percent of sales--an amount equal to the cost of the food purchased. This study also showed how these costs can be reduced by 10 percent by improved labor utilization. Application of these findings universally would bring annual savings of \$90 million. The study also indicated that far greater savings can be made by developing improved layouts, equipment and work methods.

Price-Marking Cases in Warehouse Reduces Costs. Price-marking cases in the warehouse during order assembly by use of adhesive labels showing the selling price, the retail store number, and the delivery data cost less than half as much as placing the retail price on the case in the backroom of the store. This saving of only 1/2 cent per case would amount to \$22 million annually, if applied to all the groceries sold in retail food stores. The evaluation and methods of accomplishing these savings were set forth in a report published during the year. By the end of the year more than 100 large distributors reported adoption of the method.

Improved In-Store Bakery System at Retail Food Stores. Recently many retail supermarkets have installed complete bakery departments in the store in an effort to sell more bakery goods through the appeal of freshly baked products. However, an on-premise baking operation--where the products are mixed, formed, baked, and finished in the retail store--is costly. The sales appeal can be maintained and costs reduced by receiving mixed and partially formed frozen bakery products from a wholesale bakery and completing the forming, baking, and finishing at the retail store. In total the savings from adopting this method instead of performing the entire operation in the retail store would amount to \$8 million per year for labor and \$6,000 per store in cost of equipment.

#### RESEARCH PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

Research concerned with the economics of marketing at the State Agricultural Experiment Stations is reported under the appropriate areas of work of the Multiple Use Report, Marketing Economics Division, ERS. Likewise, research dealing with facilities and transportation conducted by the agricultural engineers at the State Experiment Stations is reported in the Multiple Use Report of the Agricultural Engineering Research Division, ARS, Areas 4, 5, and 9. Related research in food science and technology is reported in the Multiple Use Report of the Utilization Research and Development Divisions.



## AREA NO. 1. PLANNING MARKETING FACILITIES

Problem. Food products from farms move through a succession of marketing facilities on the way to consumers. These facilities are used to assemble, store, prepare, and distribute food products. They are depended upon to provide an orderly and efficient channel for handling food in the proper quantities, at the least possible cost, and in the best possible condition. Many of these facilities are inefficient and, in some cases, are inadequate. Many are outdated, poorly designed, in the wrong locations, or not equipped to serve effectively. These shortcomings are unnecessary and add to the cost of marketing. They tend to increase the spread between the price received by farmers and the price paid by consumers. New technology in producing and consuming units, changes in population, innovations in marketing, changes in public wants and needs, effects of urban renewal, redevelopment, automation, changes in the size, number, and location of marketing firms, higher costs, and many public programs aimed at protecting public health and welfare affect these food marketing facilities. Because of the widespread influence of facilities used in marketing on producers, handlers, and consumers, public guidance and research assistance is necessary in planning, improving, and promoting the construction of modern marketing facilities in order to keep the food marketing system efficient and effective.

Programs in this area by State departments of agriculture, extension services, and experiment stations are usually conducted on a cooperative and informal basis with personnel of the Marketing Facilities Development Branch. Industry and private groups' work in this area is by firms that are retained to develop detailed plans and specifications for specific facilities used in marketing agricultural products. Many have little experience, and often their primary goal is to develop, promote, and sell equipment or services. Much of the work by private groups is based upon the results of USDA studies and many frequently consult with and rely heavily upon the technical knowledge of Branch personnel.

### USDA PROGRAM

Terminal Wholesale Market Planning. The Marketing Facilities Development Branch conducts comprehensive studies of terminal marketing facilities in specific urban areas. These studies are made to assist local government officials, food handlers, industry groups, and civic organizations plan for improved, modern, and efficient facilities and methods for handling food. Assistance is provided only upon request from groups of food handlers, municipal and/or State authorities, or other responsible groups who are willing to cooperate and assist in the work. In addition, there must be a clear need for improvement and there must be adequate reason to expect that improvements will be made before studies are initiated.

Assistance by the Branch is limited to the technical guidance and recommendations of specialists in food handling and facility planning. Each study is published in the interest of distributing research findings and ideas on improving food marketing facilities. The demand for this kind of work has grown and continues to grow as urban renewal, redevelopment, and other public programs dislocate existing food markets. The major study in Baltimore, Md., has been completed. A report was published for Chicago, Ill. Studies in Dayton, Ohio, and Honolulu, Hawaii, are nearing completion. Four new studies have been initiated; they are in Cincinnati, Ohio, Denver, Colo., Salt Lake City, Utah, and Oakland, Calif.

Preliminary and Followup Work in Specific Locations. Prior to committing any resources for conducting studies of terminal wholesale marketing facilities, investigations are made to determine the needs, requirements, and other factors favorable to obtaining improved facilities. After improved facilities are built, their full potential cannot be realized until the operations in them are efficient. Technical assistance is provided to bring this about as quickly as possible. Demonstrations are developed to maximize the benefits of properly designed facilities. Study is continuing on isolating particular problems in markets with improved facilities in order to develop possible solutions to them and take appropriate planning steps that will eliminate their recurrence in new markets being planned. Preliminary and followup studies in 19 locations were completed during the year or are underway.

Production Area and Independent Marketing Facilities. Most food products begin their movement in the marketing channel at facilities located in producing areas. These are usually independent marketing facilities where smaller quantities of products are assembled into large quantities and graded, packaged, stored, or otherwise prepared for movement into wholesale and retail outlets. The Marketing Facilities Development Branch provides technical assistance to operators of these facilities in order to find ways to increase their efficiency. The work is conducted upon request and with the cooperation of State departments of agriculture, State and local authorities, trade groups, State extension services, and industrial marketing and research firms. It includes research and assistance on the design, layout, location, equipment, work methods, costs, and operation procedures of poultry and egg processing plants, livestock auctions, stockyards, slaughtering and processing plants, processing facilities for fruits and vegetables and dairy products, as well as facilities required for handling other food products between the farmer and the consumer. This is a continuing program, designed to study and analyze facility needs in particular locations required to market specific commodities efficiently. Individual studies are made with owners and operators when there is a definite need for improvement and where there is ample reason to expect that improvements will be made. Improvements that result from these studies are available as guidance and demonstrations to others planning similar improvements.

The program utilized 17.2 scientific man-years, of which 8.5 were devoted to terminal market planning and 8.7 to planning production area and independent marketing facilities.

#### REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

##### A. Terminal Wholesale Market Planning

Seven urban areas were under study this year in developing plans for the improved marketing of food. Urban renewal, highway development, or other programs for civic improvement emphasize the problems of antiquated, poorly designed, and improperly located facilities in cities throughout the country. They focus attention on the major problem areas, and thus act as a stimulus in motivating city officials, wholesalers, and industry and civic organizations to improve the facilities and methods for handling all types of food commodities. Many firms operate in buildings which were neither designed nor intended for food use. This type of facility, together with inefficient handling methods, has contributed to higher costs, more waste, and unnecessary spoilage. The major study in Baltimore, Md., has been completed. Studies in Dayton, Ohio, and Honolulu, Hawaii, are nearing completion, and the reports are in the process of being published. Four new studies have been initiated: Cincinnati, Ohio, Denver, Colo., Salt Lake City, Utah, and Oakland, Calif.

1. Baltimore, Md. During the year this project was completed and a report published and released. Public presentations were prepared and presented to various officials of the city of Baltimore and the State of Maryland. Other public meetings were held for the general public and various industry groups. Development of a new wholesale food distribution center to serve the Baltimore region would result in annual savings of \$740,000 to \$990,000, depending upon the site selected. Total costs of constructing a new market were estimated at \$19.7 million. Five sites were considered for the development of a food center. The estimated cost of the 258 acres ranged from \$1.4 to \$4.1 million.

2. Dayton, Ohio. This study was conducted to assist in planning new facilities for the independent wholesale food firms in Dayton. Plans developed were for four multiple-occupancy buildings to house 55 firms that handle fruits and vegetables and other foods and one single-occupancy grocery facility. Plans included a food chain warehouse facility. A farmers' shed containing 2,400 feet of covered marketing space, a restaurant, and 20 offices for brokers and other marketing tenants are provided. The total cost of the facilities is estimated at \$4.8 million. Four possible sites for the development of new facilities are discussed in a report which will be published soon. This project is completed and all further work will be of a followup nature under TF 1-26.

3. Honolulu, Hawaii. This project is essentially completed. The report is now being reviewed by the editors. A public presentation of the findings will be made to the wholesale food trade, city officials, financial and construction interests, and others interested in improved wholesale food handling facilities in Honolulu. The State of Hawaii is paying for the construction of a model of the proposed market and support material to be used at the public presentation. Specific details concerning the study will be made available upon clearance of the publication.

4. Cincinnati, Ohio. A general survey conducted by the Greater Cincinnati Chamber of Commerce indicated that many food wholesalers in the city would face serious relocation problems in the near future. As a result, a request for assistance was received by this Branch to determine the best course of action for the wholesalers. Field work for our study is completed and analysis of the data is underway. An advisory committee has been organized in Cincinnati which consists of representative wholesale food dealers, city officials, local banking officials, and members of the local chamber of commerce. This committee will serve to acquaint the chamber and local business interests with the problems and operations of the food industry. The food dealer representatives will eventually evolve into a nonprofit corporation representing firms which will find it necessary to relocate. The corporation will provide an instrument for the development of the nucleus of a food distribution center and aid in its orderly growth.

5. Salt Lake City, Utah. Assistance in planning new food distribution facilities for Salt Lake City was requested by the Governor, the Chamber of Commerce, Pro-Utah, food merchants, and growers. The study was initiated this year. Meetings were held with personnel of Utah State University. They have agreed to evaluate the need for new farmers' market facilities and supply other data for the study. The collection of basic data is complete and analysis of the data is underway.

6. Oakland, Calif. Contacts have been made with the Mayor's office and the city manager of Oakland concerning the wholesale food distribution study now underway there. Direct cooperators on the project are the Industrial Development Commission and the City of Oakland. Initial data collection, involving more than 200 firms, is complete. Lines of communication have been established with the University of California, Berkeley, the California State Department of Agriculture, Urban Renewal, City Planning, traffic, and other local agencies, and EDA. Site selection will begin in the near future.

7. Denver, Colo. The general wholesale food survey has been completed for 107 independent food wholesalers in the Denver metropolitan area. In addition, the Denver Union Stock Yards Company, the Denver Planning Office, the Denver Urban Renewal Authority, the Colorado State University, the Colorado Department of Agriculture, the Denver Chamber of Commerce, the

Denver Forward-Metro, and other interested parties, both public and private, have been contacted and advised of the study. Many of these groups have volunteered their assistance in conducting the study.

B. Preliminary and Followup Work in Specific Locations

Exploratory investigations must be made before any major study is undertaken. The nature, extent, and needs for the study must be analyzed in order to allocate the proper personnel and resources. After studies are completed, followup assistance is often necessary to help planners in problems of financing, organization, construction, and management. Where new facilities have been built, followup assistance is frequently provided to implement the most effective operations that will bring about maximum savings in food handling costs. Studies are also made to serve as guidelines for the future in the continuing effort toward developing further improvements in food marketing facilities. Last year, projects at 19 locations were completed or were underway in this program. A report on the development and operation of wholesale food distribution facilities for cities is being revised prior to publication. Innovations in marketing create problems, even in modern markets. This report will assist in providing answers to specific problems and also serve as a guide in developing plans for future markets.

1. Baltimore, Md. Market Authority legislation has been approved by Governor Agnew which appropriates \$4 million in general obligation bonds and \$6 million in revenue bonds to assist in the construction of Baltimore regional wholesale food distribution facilities as outlined in MRR-783. Technical assistance was provided firms planning to move to new facilities.
2. New York, N. Y. Technical assistance in selecting the proper design and systems for providing refrigeration was given food wholesalers moving to the new food center at Hunts Point. Assistance is also being provided city officials and planners in developing second phase plans of the new food center.
3. Chicago, Ill. Lake Calumet Food Center Development Corporation, a nonprofit organization, plans to construct a \$225 million wholesale food distribution center on Chicago's south side. The center will be built on a 640-acre site. Initial financing to complete the first phase of the project will involve the sale of a \$100 million bond issue. Work is slated to begin late this year, with the first phase to be completed in 1968.
4. Pittsburgh, Pa. Followup assistance was provided the organizers, planners, and developers of the new wholesale food center to be built in the Chartiers Valley area. Workshops were held for food wholesalers who will move into the new market to acquaint them with the most efficient methods of operation and refrigeration.

5. Boston, Mass. Groundbreaking ceremonies were held this fall for the New England Produce Center to be built at Everett-Chelsea, Mass. Continued assistance is being provided both developers of this market and the food wholesalers who will occupy it. Progress continues on the initial section of the food center. Technical assistance was provided firms planning to move to new facilities.
6. Milwaukee, Wisc. The Milwaukee Market Authority Board has accepted a deposit from each of the fresh fruit and vegetable wholesalers on the Broadway Street Market as good faith money to be used for the selection of an architect. The Board will select one of five architects under consideration. The architect chosen will then draw specific plans based on recommendations in MRR-664. Alternative plans were reviewed by the Branch this year.
7. Huntington, W. Va. A case study was completed to develop an efficient demonstration operation for food wholesaling in the proposed new food center planned for Huntington.
8. Springfield, Mass. Technical assistance was provided to architects planning the new wholesale food center.
9. San Juan, P. R. As a result of our studies of marketing facilities in Puerto Rico many improvements in the marketing system for the Commonwealth have been made. Consideration is now being given to building another distribution center on the southern side of the island at Ponce similar to the one built in San Juan.
10. Washington, D. C. Plans were reviewed for a new building to house fresh fruit and vegetable wholesalers on the Union Terminal Market. Construction is to begin in the near future.
11. Producing Areas. Supplemental assistance and planning were provided in fruit and vegetable marketing facilities in Michigan, Florida, North Carolina, and South Carolina. Followup work was conducted on an egg processing plant in New York.
12. Preliminary investigations were conducted in Cincinnati, Ohio, Salt Lake City, Utah, Oakland, Calif., and Denver, Colo.

C. Improving Refrigeration Facilities for Food Products

A research contract was recently completed which determined the most efficient and least costly refrigeration systems in given food marketing facilities. This work will result in specific data, material designs, and evaluations on refrigeration that will provide criteria for planning efficient systems for wholesale food markets. The study proved that floor insulation is economically justified even for the 50° F. coolers. Another

significant finding is that economies achieved by central refrigeration permit thinner insulation than commonly used. Technical assistance concerning refrigeration and facility design features should be greatly enhanced as a result of this work.

D. Determination of Possible Annual Volume of Produce Handled in Specific Situations

A research contract was developed and let to determine objectively the annual volume of product that could be handled by specific kinds of wholesale food firms operating in a specific kind of facility and in specific amounts of space. It is known that specific volumes of certain food products can be handled in a given amount of space, but there are indications guidelines are changing. Research is needed to determine volumes that can be handled today in order that planners can be assured they are providing not only the most efficient facilities possible, but also the correct number of facilities that should be built.

E. Interdepartment Cooperation

A technical assistance contract from Economic Development Administration, U. S. Department of Commerce, and executed by the Regional Economic Development Institute included workshops to help wholesalers in Pittsburgh, Pa., decide on layouts and operation techniques in new facilities. The Branch participated in these workshops. EDA activities in Miami, Fla., and Oakland, Calif., are also being coordinated with current work projects being conducted by the Branch.

F. International Cooperative Programs

1. The Republic of France honored the Division Director by presenting him with a gold medal and a certificate naming him "Chevalier de l'Ordre du Merite Agricole." The action was an expression of appreciation by the French government for the assistance given over a prolonged period in helping bring about improvements in the methods of handling food between farms and consumers, and for his having served as chairman for a portion of a 45-nation conference held in Paris on the subject of Supplying Food to Large Cities and having spoken at the conference. Other consultations were held with officials of foreign countries who were involved with developing, designing, and constructing improved facilities for distributing food in their countries. Notable among these were England, Japan, Iran, and Australia.

2. Technical assistance and guidance is being provided countries in South America in the development of efficient wholesale food marketing facilities. Notable among these is Brazil, where work is being carried out in Sao Paulo, Rio de Janeiro, Belo Horizonte, and Vitoria. The work in Sao Paulo is 80 percent completed, and for Vitoria, Esperito Santo, construction in two

of the central retail market buildings is nearing completion. Top priority is to be given construction of a wholesale food distribution center in Belo Horizonte. There is nothing new to report on Rio de Janeiro. In addition to helping plan modern centers, assistance is also provided municipal and independent food handlers to help improve present marketing practices. Requests for advice and assistance in marketing and product distribution are being made from sources not directly connected with governmental organizations. Work has already begun with one cooperative group and the cooperative credit program now underway will require consideration of all major aspects of marketing and handling food commodities that are related to the activities of some of the cooperatives which will receive financial assistance under the program.

#### G. Production Area and Independent Marketing Facilities Planning

Thirty-seven studies were conducted in 20 States to develop improved production area marketing facilities. Thirty-two are completed and five are in process of completion. Of these, 11 were for poultry and egg products, five were for livestock and meat products, 12 for grocery products, four for fruits and vegetables, and five for dairy products. The study evaluating the efficiency of a terminal marketing system for livestock is progressing satisfactorily. Efficiencies in Poultry and Egg Marketing, a television program designed to reach most processors and producers in eastern Pennsylvania, was prepared in cooperative with the Pennsylvania State Inspection Service. Many consultations were held throughout the year on planning improved marketing facilities in specific locations and technical guidance was provided plant owners and operators, planning engineers, builders, equipment manufacturers, State and local officials, industry representatives, and others engaged in or interested in developing improved and more efficient marketing facilities.

1. Poultry and Poultry Products. This project deals with planning improved facilities used in marketing poultry and poultry products. These facilities may be found wherever poultry and eggs are assembled, processed, graded, packaged, frozen, stored, shipped, or otherwise handled in preparation for retail marketing. Studies are made with emphasis on planning facilities that can serve as a guide or stimulus to other firms and individuals in developing ways to improve their own operations.

Eleven studies were conducted last year and they included developing improved layout and operation designs for both new plants to be built and old plants to be remodeled. These were studies of individual facilities and were made with an emphasis on planning improvements that would demonstrate to others ways to improve their own operations. The potential annual benefit to accrue directly from these 11 improved facilities is estimated to be over \$300,000. Approximately half of the improved operations have been implemented and others are in the process of implementation.

2. Livestock and Meat. Five studies were made to develop improved facilities and operations for marketing livestock and meat. These were facilities for the handling of live animals and the processing and distribution of meat and meat products in Kansas, New York, Maryland, Colorado, Georgia, and Mississippi. In addition, a study of improving the complete marketing system of livestock and meat products has been combined with the Division Livestock Panel's work. This panel will continue to study and evaluate all the efficiencies of a terminal livestock and meat distribution complex for assembling, marketing, slaughtering, and inspecting livestock and for processing, storing, handling, and distributing meat and meat products.

3. Grocery Warehousing. Twelve studies were conducted last year in improving the facilities and methods for warehousing grocery products. Individual operations in eight States were studied and improvements were developed to help reduce the costs of marketing grocery products. Also, a special study was conducted to examine the relative costs and advantages of using truck bed height docks for receiving and loading out fruits and vegetables in wholesale facilities. The information developed in this study will be published as part of the study of wholesale facilities in Honolulu, Hawaii, as a marketing research report.

4. Fruits and Vegetables. During last year, marketing facility development assistance was furnished in Michigan, South Carolina, North Carolina, and Florida. Four studies were made in these States to improve the facilities and methods used for assembling, cooling, sorting, grading, packing, and distributing fruits and vegetables. The second largest assembly market in the United States, located at Benton Harbor, Mich., is being rebuilt on the outskirts of the city as a cost exceeding \$750,000. Building design, facilities layouts, cost estimates, recommended fee and rental schedules, a financial prospectus, and suggested revisions in operating methods were furnished the city during the first half of the year. Work is progressing on the possible relocation of the Charleston Farmers' Market and planning improvements for the Raleigh State Farmers' Market and Jacksonville State Farmers' Market.

5. Dairy Products. Five studies were made last year ranging from designing plant layouts and operations for new facilities to developing plans for remodeling old ones. Studies were conducted in Indiana, Tennessee, Maryland, New York, and Maine. Benefits derived from these studies resulted in a savings of approximately \$325,000 annually to process and handle current production. A potential savings of \$575,000 annually is projected to process and handle a planned increase in production. Studies conducted during the year were more detailed and complex than previous studies.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Crow, W. C., August 1966. Developing Wholesale Food Market Centers in Metropolitan Areas of the United States. Paper presented at the 17th International Horticultural Congress, College Park, Md.

Boles, P. P. and Overheim, R. K., August 1966. Wholesale Food Distribution Facilities for Huntington, West Virginia. ARS 52-13.

Toth, S. J., September 1966. Refrigeration--Why, What, and For How Much? Paper presented at Workshop for Wholesalers Relocating to Improved Facilities, Pittsburgh, Pa.

Crow, W. C., September 1966. The Challenge of the New York Market. The Packer.

Hanlon, P. J., October 1966. Improved Wholesale Food Distribution Facilities for Dayton, Ohio. Paper presented at public presentation in Dayton, Ohio.

Olson, J. A., October 1966. Layout Planning for Wholesale Meat Facilities. Paper presented at Workshop for Wholesalers Relocating to Improved Facilities, Pittsburgh, Pa.

Kozlowski, R. G., October 1966. Product and Material Handling Methods for Poultry and Egg Wholesalers. Paper presented at Workshop for Wholesalers Relocating to Improved Facilities, Pittsburgh, Pa.

Taylor, E. G., October 1966. Baltimore Wholesale Food Distribution Facilities. Paper presented at public presentation, Baltimore, Md.

Taylor, E. G. and Miller, F. J., Jr., February 1967. Baltimore Regional Wholesale Food Distribution Facilities. Marketing Res. Report No. 783.

Holland, R. L. and Blackmore, W. E., March 1967. Chicago Wholesale Food Distribution Facilities. Marketing Res. Report No. 790.

Crow, W. C., April 1967. Partners in Progress. Paper presented at annual meeting of National Association of Produce Market Managers, Miami Beach, Fla.

Seabold, T. J., April 1967. Engineering and Food Marketing. Student Conference, Region 8, American Institute of Industrial Engineers, Fargo, N.D.

Seabold, T. J., May 1967. Developing Wholesale Food Market Centers in Metropolitan Areas of the United States. Paper presented at Platte River Redevelopment Committee Meeting, Denver, Colo.

AREA NO. 2. DAIRY PRODUCTS - MARKETING FACILITIES,  
EQUIPMENT AND METHODS

Problem. The equipment, work methods, and facilities used by many dairy plants are obsolete and the production per man-hour employed relatively low. A major factor contributing to this obsolescence is the development during the last few years of new types of equipment which can be brought under automatic control. Because of the investment required and the uncertainties of the returns they would obtain, plant operators have been reluctant to shift to automated equipment on a piecemeal basis. They also have been reluctant to build new plants because of a lack of guidelines and criteria on automated plants. However, studies indicate that it is possible in fully automated plants to increase the productivity of labor 100 percent or more, to improve the qualities of the finished products, and to develop better management-employee relations. Engineering layouts and operating criteria therefore are needed for automated plants to provide guides to plant operators in making the shift from their present equipment and facilities. Most dairy plants lack the technological and engineering skills necessary to plan and develop suitable plant layouts and designs, or to select the types of equipment needed and the controls necessary for full automation. Automated equipment and processes for some types of dairy plants still largely are lacking or are nonexistent. Therefore, engineering research also is needed to develop equipment and processes for automating these plants in order to increase labor productivity and improve product quality.

USDA PROGRAM

The Department has a continuing long-term research program involving agricultural engineers and dairy technologists engaged in applied research to develop improved methods, equipment, operating criteria, and plant layouts for dairy plant operators.

Current research covers the development of layouts and operating criteria, based on current technology, for automated dairy product plants. It features the use of remotely controlled air operated valves, electronically controlled devices, and highly mechanized equipment to facilitate automated processing and CIP cleaning in dairy plants. The work is carried out at Hyattsville, Md., and Columbia, Mo. Work in the Hyattsville, Md., office consists of checking, organizing, and preparing for publication a series of reports prepared under contract. Work at the Columbia, Mo., field location, which is conducted in cooperation with the Missouri Agricultural Experiment Station, consists of collecting, analyzing, and preparing for publication engineering data, from studies in both laboratories and commercial plants, needed for efficient utilization of automated procedures in fluid milk plants.

The Federal effort devoted to research in this area is 1.3 scientific man-years; 1.0 man-year for intramural work and 0.3 man-year for program leadership.

#### REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

##### A. Layouts and Operating Criteria for Automated Dairy Product Plants

At Hyattsville, Md., work was continued on the preparation of a series of contract reports covering the development of layouts and operating criteria for different types of automated dairy product plants. Three of the six contract reports have been published. The status of the work on the three remaining reports in this series is as follows:

1. Plants Manufacturing Cottage Cheese, Cream Cheese, and Cultured Milk and Cream. Changes recommended by Division Editor to improve clarity are underway. Results previously covered.
2. Plants Manufacturing Cheddar Cheese. Manuscript completed and ready for review at the end of the report year. Results previously covered.
3. Plants Manufacturing Sweet Cream Butter and Dried Nonfat Milk. The manuscript for a Department publication, based on the contractor's report, was about 90 percent complete at the end of the report year. Results of this research were covered in last year's report.

##### B. Increasing Efficiency Through Optimum Utilization of Automation in Fluid Milk Plants

At Columbia, Mo., research using the University of Missouri dairy plant as a laboratory for tests and experiments on automation problems was continued. Installation of the automated equipment in the University dairy plant was completed. The following items were operational at the end of the report year:

1. The valving assemblies for the raw and pasteurized milk tanks.
2. The automated CIP (Cleaning-in-place) system for the milk storage tanks and processing line.
3. The automated sanitizing of the processing line.

Labor requirements on the partially automated plant were determined during the year as different components of the automated equipment were installed. Control equipment was designed and installed, which permits the milk processing line to be completely CIP cleaned. Use of the system reduces the labor required for cleaning of the processing lines since no equipment must be disassembled and washed by hand. Approval of the system for

test purposes in the University dairy plant has been granted by the Division of Health of Missouri and the control circuitry has the tentative approval of the U.S. Public Health Service.

Experiments to determine the parameters for cold water cleaning and meter type measurement of detergents into a CIP system were underway at the end of the report year.

#### PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

##### Layouts and Operating Criteria for Automated Dairy Product Plants

Tracy, P. H. 1966. Layouts and Operating Criteria for Automation of Dairy Plants Manufacturing Ice Cream and Ice Cream Novelties. Marketing Research Report 750. December 1966.

##### Increasing Efficiency Through Optimum Utilization of Automation in Fluid Milk Plants

Anderson, M. E. and Morris, H. A. 1966. This Problem of Waste Disposal - An Analysis of Systems Used by Selected Dairy Plants. (Series of three articles) Manufactured Milk Products Journal. August-October, 1966.

### AREA NO. 3. FIELD CROPS - MARKETING FACILITIES, EQUIPMENT AND METHODS

Problem. Differences in varieties of individual field crops and in the environments of producing areas where they are conditioned and stored, together with advancing techniques in cultural and harvesting practices, require new or modified marketing facilities, equipment, and methods. Such changes are essential to the efficient and economical handling, conditioning, and storing of these crops and to maintaining their quality. There is a need for improved designs for facilities based on functional and structural requirements, which will expedite the movement of commodities into, within, and out of the facility. There is also a need for handling and conditioning equipment which will minimize labor and other costs and also minimize the extent of physical damage (breakage) to the grain as it is handled into, within, and out of marketing facilities. More knowledge is needed of the relative efficiency of various handling and conditioning methods so that improved or revised methods and equipment can be developed to perform necessary operations.

#### USDA PROGRAM

The Department has a long-term program involving engineers engaged in both applied and basic research on, as well as application of known principles to, the solution of problems of handling, storing, and conditioning field crops in marketing channels. Grain aeration and drying research is carried out at Manhattan, Kans., on corn, wheat and grain sorghum and at Lafayette, Ind., on corn, in both laboratory and pilot-scale facilities and in commercial storages; in cooperation with the Agricultural Experiment Stations of respectively Kansas and Purdue University (Indiana), the Market Quality Research Division, and with grain storage firms; and is supplemented by a research grant by the Corn Industries Research Foundation made through Purdue University. Investigations designed to determine the extent and causes of physical damage (breakage) to grain by handling equipment used in marketing facilities are conducted at Manhattan, Kans., in cooperation with the Kansas Station; and are supplemented by a research contract with Cargill, Inc., Minneapolis, Minn. Investigations on the basic theory of dynamic and static pressure phenomena in grain under storage conditions, by theoretical analysis and simulation, are conducted under a research contract with Dr. J. D. Isaacson, St. Louis, Mo. Studies to develop improved techniques and equipment for uniformly blending lots of seed are conducted under a research cooperative agreement with the Mississippi Agricultural Experiment Station, the Consumer and Marketing Service, and the Field Seed Institute of North America. Research on the handling of cotton bales and the humidification of storage compartments is conducted in cooperation with Calcot, Ltd., Bakersfield, Calif., at selected warehouses in California and Arizona. Research on the handling, drying, aerating, storing, and shelling of peanuts is conducted by the Albany, Ga., field office at laboratory facilities.

in Dawson, Ga., and pilot-scale facilities at Dawson, Ga., and Holland, Va., in cooperation with the Agricultural Experiment Stations of respectively Georgia and Virginia, the Market Quality Research Division, and with various industry firms; and is supplemented by a research cooperative agreement with Tuskegee Institute, Tuskegee, Ala. Studies on the handling, drying, aerating, and storing of rice are conducted at Beaumont, Tex., in cooperation with the Texas Agricultural Experiment Station, the Market Quality Research Division, and at commercial facilities in Texas, Arkansas, Louisiana, and Mississippi. Research on aeration and storage of cottonseed is conducted at Stoneville, Miss., in cooperation with the Mississippi Agricultural Experiment Station and at commercial facilities in Mississippi; and is supplemented by research cooperative agreements with the Mississippi Station and the Texas Engineering Experiment Station, College Station, Tex. Studies on the handling of tobacco on sales floors and the storage of unprocessed tobacco are conducted at Raleigh, N. C., in cooperation with the North Carolina Agricultural Experiment Station and selected warehouses; and are supplemented by research and broad-form cooperative agreements with the North Carolina Station and the Carolina Warehouse, Inc., Fuquay-Varina, N. C.

The Federal effort devoted to research in this area during the Fiscal Year 1967 totaled 19.4 scientific man-years, including 6.4 man-years for contracts and research cooperative agreements: 3.7 to grain aeration, storage and drying; 4.1 to the effect of handling equipment and methods on extent of physical damage to grain; 1.0 to the handling of bales of cotton and to the humidification of cotton storage compartments; 3.8 to the handling, drying, aerating, storing, and shelling of peanuts; 1.4 to the handling, drying, aerating, and storing of rice; 1.3 to the aeration and storage of cottonseed; 1.2 to the handling of tobacco on sales floors; 0.7 to the basic study of grain pressures; 0.2 on uniformly blending seed lots; and 2.0 to program leadership.

#### A. Drying, Aerating, Storing and Handling Rice

1. Drying. At Beaumont, Tex., tests using a pilot-size continuous-flow heated-air dryer were conducted to determine the effect of various velocities of air heated to 115° F. on the rate of drying, milling yield of rice, and fuel and power requirements. Air velocities tested ranged from 102 to 167 f.p.m. at the point where the air entered the rice. Results indicated that the highest air velocity increased the drying rate by one-third with no significant decrease in milling yield, but at the expense of an increase in fuel and power requirements. This increase in drying rate was confirmed by laboratory-scale tests where the rate increased 100 percent when the air velocity was changed from 3.3 to 42.5 feet per minute. Results of other tests showed that the change in milling yield of the rice was inversely proportional to the final rice moisture content within the 10-14 percent moisture contents tested. The amount of head rice generally increased 1 percent when the final moisture content of the rice was decreased 1 percentage point.

2. Aeration and Storage. At Beaumont, Tex., the study of using aeration for maintaining the quality of undried rice was continued. Batches of green rice

were stored for 21 days and sampled periodically. Quality tests of samples included a determination of grade by C&MS Grain Division personnel. Rice at three different initial moisture contents was stored simultaneously with all bins aerated at a rate of 1 c.f.m. per barrel. Rice moisture contents were approximately 24, 22 and 20 percent (wet basis). Relatively large amounts of aflatoxins were found in rice stored at the high (24 percent moisture content) during warm weather. No significant amount was detected in rice going into storage at 20 percent moisture content during warm or cool weather. Rice having an initial moisture content of 24 percent was stored for 10 days during cool weather before detectable amounts of aflatoxin were found. When aflatoxin was detected in a sample a high percentage of rice kernels was infected by molds. This high percentage of infection was not necessarily accompanied by a large amount of aflatoxin. In general, rice samples which graded U. S. No. 1 were free of aflatoxins, although significant amounts were detected in a few of these samples.

3. Handling of Rough Rice at Commercial Dryers. Studies of operating methods, labor utilization, conveying machinery and company records were made at three commercial rice dryers in Texas and Louisiana during the 1966 harvest season. Rice drying costs; including amounts for labor, gas, electricity, depreciation, taxes, insurance and interest; averaged \$0.35 per barrel of rice dried by a new plant drying a large volume of rice as compared with \$0.76 per barrel for an older plant handling a smaller volume. Studies indicated that conveying equipment operated at less than full capacity at all three dryers. Improved utilization of equipment was obtained by using photoelectric relays to warn operators of an impending choke-up, ammeters to indicate the proper loading of conveyor motors, and a bypass on scalperators to divert part of the rice directly to a drying unit. Sampling selected lots of rice before and after dryer passes indicated these three drying plants were successful in maintaining the milling quality of rice although one plant used the dryeration process while the others tempered rice at a high temperature.

4. Bulk Handling of Milled Rice. Tests were continued to determine the amount of breakage resulting from dropping (free fall) bulk milled rice from different heights. In general, as the height of free fall increased up to 60 feet, the amount of breakage increased. Medium-grain rice was more resistant to breakage than long-grain rice. More breakage resulted from dropping rice on a flat steel surface than on a flat concrete surface or on a layer of rice. Inclining the steel surface 45 degrees reduced the amount of breakage. Rice at a moisture content of 13 percent was more resistant to breakage than rice at 11 percent. The amount of breakage increased slightly when rice of 11 percent moisture content was dropped through air of 50 percent relative humidity as compared with rice dropped through air of about 100 percent relative humidity. Rice temperatures in the range between 30° F. and 80° F. had no effect on the amount of breakage when rice was dropped through air having a temperature of 62° F. and relative humidity of 88 percent.

B. Shelling, Handling, Drying, Aerating and Storing Peanuts

1. Shelling. At Albany and Dawson, Ga., tests were conducted to evaluate four different commercial makes of peanut shellers. Operating speeds of the sheller cylinders were varied from 165 to 325 r.p.m. and peanuts were varied between Spanish-, Runner-, and Virginia-types. The results showed all four makes of shellers increased the amount of split peanut kernels as the cylinder speed increased. Increasing the cylinder speed increased the shelling rate of each type of peanut only at the lower speeds tested. As these increases in the rates of shelling were accompanied by increases in the amount of split kernels, a compromise between minimum damage and maximum shelling rate is necessary. Tests results also showed that sheller grate size affected peanut shelling differently when the make of sheller was changed. In some tests grates with small openings shelled faster and caused fewer split kernels than grates having larger openings, while in other tests the reverse occurred. Results of tests on sheller bar design showed that the various bars tested had little effect either on the peanut shelling rate or amount of split kernels.

Tests on presizing farmers stock peanuts and sizing shelled peanuts were continued with emphasis on determining the physical characteristics of various peanut types. The average pod size of Spanish- and Runner-type peanuts was 26/64 inch and for Virginia-type was 36/64 inch. Examination showed kernels of Spanish- and Runner-type peanuts close to the hull in small pods. These kernels were split most often during shelling. Conversely, the hulls were much larger (7/64 inch) than the kernels in Virginia-type peanuts, resulting in the larger kernels being split during shelling.

New techniques investigated in shelling peanuts included a centrifugal sheller having a stationary center cone with rubber fingers to rub unshelled peanuts against metal grates. Preliminary tests showed less damage to peanuts but a lower capacity than conventional commercial shellers. Also, limited tests showed Virginia-type peanuts could be shelled with only one-stage, but Spanish- and Runner-types required several stages, the same as conventional shellers.

2. Handling. Tests conducted on two sizes of bucket elevators moving farmers stock peanuts showed that at belt speeds below 380 f.p.m., 9 by 5 1/2-inch buckets on a 12-inch spacing handled more peanuts than the volume of the buckets due to mounding of the peanuts. The maximum rate, 19 tons per hour, occurred at a bucket speed of 380 f.p.m. Reducing the bucket spacing from 12 to 6 inches (or doubling the number of buckets) reduced the maximum handling rate of 18 tons of peanuts per hour at a cup speed of about 300 f.p.m. An elevator having 8 1/2-inch spacing of 6- by 4-inch cups handled 6 tons of farmers stock peanuts per hour at the optimum bucket speed of 320 f.p.m. Reducing the spacing to 4 1/4 inches increased the handling rate only by 1 ton per hour. An evaluation of mechanical damage to the peanuts by the bucket elevator tests was made from official grade data. The results showed an increase of about 0.1 percent in loose shelled kernels and splits combined for each pass through the elevator, while bucket speed had no significant effect.

Tests and experiments, conducted at Tuskegee Institute, Ala., under a research cooperative agreement, to determine the angle of repose and coefficient of friction of farmers stock peanuts were completed but the final report had not been received at the end of the report year.

3. Drying. Tests were conducted on Spanish-, Runner-, and Virginia-type peanuts at Dawson, Ga., and on Virginia-type peanuts at Holland, Va., using an experimental belt dryer. Constant heated-air temperatures of 115°, 130°, and 145° F. were used for intervals of 7.5, 15, 30, and 60 minutes. In one series of tests, 160° F. air was employed initially--then the temperature progressively reduced as drying progressed. A total time of 1 hour per drying pass was used. In the 7.5 and 15 minute exposures to heated air, peanuts were alternately exposed to equal intervals of ambient air. The peanuts also were aerated three or more hours between passes using ambient air at a rate of about 1 c.f.m. per cubic foot of peanuts. Shelling the dried Spanish- and Runner-type peanuts caused less than 5 percent splitting regardless of drying treatment with no significant correlation between drying air temperature and milling quality. However, shelling Virginia-type (Florigiant) peanuts caused an average outturn of split peanuts of about 4, 7, 10 and 14 percent for respective drying air temperatures of ambient, 115°, 130° and 145° F. Shelling Virginia-type (56R) peanuts showed 30 percent more splitting when the heated air temperature reached 145° F. Shelling results also showed exposure times of 15 or 30 minutes to heated air caused fewer split peanuts than an exposure time of 60 minutes. Taste-panel results on the Spanish- and Runner-type peanuts indicated only one lot of Runner-type, dried at 145° F. for 60 minutes (a severe drying treatment), was off-flavor. Although aflatoxin was found in some samples of peanuts, its presence could not be related to the drying treatment. Increases in the rate of drying were directly proportional to increases in temperature and exposure to heated air. The longer aeration period caused a 1.3 to 3.7 times higher drying rate of the peanuts than rates obtained in previous years.

Infra-red drying tests were conducted where Spanish-, Runner-, and Virginia-type peanuts were exposed in a moving single layer for 1, 2 and 4 minutes, then aerated for 3 or more hours between exposures. Results of official grade determinations showed that significant milling damage occurred only in peanuts in some of the 4-minute exposure tests. Quality tests by Market Quality Research Division showed significant off-flavor of the peanuts occurred only in some of the 4-minute exposures. The presence of aflatoxin could not be related to the drying treatment. An examination of the drying rate showed that the infra-red method dried peanuts about 30 times faster than the experimental belt-dryer.

#### C. Grain Aeration and Drying

1. Aeration. At Manhattan, Kans., field studies on aerated flat-type steel grain storages are now complete. All of the grain was loaded or transferred out of these storages by the cooperators.

Grain sorghum was stored in a 100-foot wide flat-storage for four years at Hastings, Nebr. This storage was equipped with an aeration system using lengthwise ducts and fans that provided adequate air distribution through the 16 to 30 feet of grain depth. The mixed and loaded grain sorghum was officially graded No. 2. Grain sorghum taken from the center peaked surface to the two-foot depth was sample grade due to musty and damaged kernels. Fatty acid content of the sample-grade grain ran from 80 to 150 values, while the No. 2 grain ranged from 60 to 80 values. A second storage, 60 feet wide, was observed during an hour's unloading operation of the grain sorghum which had been stored in place for 10 years. This grain was in good condition except for about 18 inches of the surface layer which graded "sample" as a result of moisture migration and high temperatures from summer heat.

At Sterling, Kans., 500,000 bushels of wheat stored in a 140-foot wide by 160-foot long flat storage for 8 1/2 years were in uniformly good condition when unloaded. All of the grain was old crop wheat when the storage was filled in 1958. The averages of five samples taken during unloading were as follows: Test weight 61.1 lbs./bu.; moisture content 10.5 percent; protein 13.25 percent; sedimentation test value 35.8; germination 5.0 percent; and fat acidity 67.5 (mg. KOH per 100 g. dry basis).

Studies were continued on the effectiveness of a two-fan, crossflow, ventilation system (as described in ARS 52-20) for conditioning wheat and grain sorghum. At Abilene, Kans., a test bin was filled with wheat which averaged 11.1 percent moisture content. However, the bin also contained a layer of 500 bushels of 18-19 percent wheat. After 5 days with no fan operation, the temperature of this wet layer increased 9° to 109° F. Fan operation reduced this temperature to 88° F. in 28 hours. Again with no fan operation, the wet layer increased to 111° F. in 2 weeks. The fans were restarted and the temperature lowered to 82° F. in 24 hours. Samples of wheat obtained during unloading at the end of 5-week storage tested 11.2 percent moisture. In another test results of operating a crossflow system on newly harvested grain sorghum showed the initial grain sorghum moisture content of 14.7 percent was reduced to 13.8 percent. Fan operation was continuous for 29 hours in October, and 30 hours in both November and in December. During this time the initial grain sorghum temperature of 64° was reduced to 31° F.

The study to determine the effect of ambient air temperature on the temperature of wheat in static (unturned) storage was completed. The wheat, stored in a concrete upright storage (18 feet in diameter and 110 feet high) was unloaded in July after a 29-month storage period. Results indicate that although the wheat was marketed in good condition, initial germination of 63 percent was reduced to 27 percent and initial fat acidity of 27 was increased to 69. Analysis of the transient heat transfer in this bin is continuing, pointing to a prediction equation for wheat temperatures at a given location in a bin.

2. Drying. At Lafayette, Ind., the results of the mathematical simulation and laboratory testing of the basic methods of exposing grain to air heated to temperatures in the range of 200°-400° F. were summarized and two manuscripts prepared. Comparison of the three drying methods - crossflow, counterflow and

concurrent flow - showed the highest moisture removal rate per foot of grain bed depth using the counterflow method. Concurrent flow drying produced corn of slightly higher quality than the other two methods. The crossflow method overdried the grain on the air input side and underdried it on the air exhaust side. The mathematically developed drying models predicted (with acceptable accuracy) the performance of each of three basic dryer designs. The final moisture contents predicted for concurrent flow drying averaged only 0.5 percentage points below those obtained in laboratory tests in a model dryer. With the aid of a high-speed digital computer it was possible to study dryer performance over a range of variables that would be difficult and time consuming to duplicate in field or laboratory testing.

The study was continued on determining the effect of heat drying on the equilibrium moisture content (EMC) of corn. Shifts in the whole kernel EMC were again shown to be related to the severity of the drying treatment. Evaluation of the EMC of the physically separable parts of the corn kernel is not complete. Partial results indicate that heat drying may shift the EMC of some of the kernel fractions more than others.

Comparison of upward and downward airflow for cooling batches of hot corn accumulated from a continuous flow heated-air dryer showed fewer problems from the condensation of water vapor when downward air movement was used. With upward airflow there was more wet corn next to the bin walls and at the corn surface. Although there are some operational advantages and a 4-6 hour saving of time per batch if upward airflow is used, the corn should be moved after cooling. The resultant mixing of the wet and dry corn during moving eliminates most of the problem associated with moisture accumulation. If the corn is stored in the bin where it is cooled, downward movement of the cooling air is recommended. A downward flow rate of only 0.1 c.f.m. per bushel was satisfactory in a bin insulated with 1" of polystyrene foam.

The storage of field-shelled corn at 22-23 percent moisture under aeration and refrigeration was only partially successful. Intermittent aeration with outdoor air at temperatures between 35° and 45° F. resulted in 94 percent of the seeds becoming infected with Penicillium after 22 weeks of storage. Where the interseed air was circulated through a refrigerator to maintain corn temperatures between 40° and 50° F., a similar mold invasion occurred in only 8 weeks of storage. Of the treatments used, the best storage conditions were maintained by continuous ventilation with outdoor air. The moisture content of this corn was reduced more rapidly than that in the other tests and reached an average of 16.2 percent after 20 weeks and 13 percent after 33 weeks. The aeration airflow rate in all tests was approximately 0.6 c.f.m. per bushel.

Laboratory tests were conducted on the blending of corn of different moisture levels to yield an average moisture content of 15 to 15 1/2 percent. When the spread between the moisture levels of a 50-50 blend was 10 percent (percentage points), a difference of 2.7 percent persisted after 20 days of storage at 5° C. At 25° C., the difference was 1.3 percent after 20 days. When the initial difference in moisture levels of the blends was 5 percent, the moisture

difference after 20 days was 1.6 percent and 0.7 percent under 5° and 25° C. storage. Thus, moisture equalization was reached faster at 25° than at 5° C. Also, the nonuniformity of the final moisture content increased as the spread increased between the moisture levels of the lots blended. Aeration at approximately 2 c.f.m. per bushel failed to increase the rate of moisture equalization or reduce the final spread in moisture content.

D. Effect of Handling Equipment on Physical Damage to Grain

1. At Minneapolis, Minn., tests are being continued under a research contract with Cargill, Inc., to determine the extent and causes of physical damage (breakage) to grain by handling equipment used in commercial facilities.

Tests were conducted to determine the amount of breakage occurring during the handling of wheat having a minimum temperature of 75° F. as compared to wheat having a maximum temperature of 50° F. In every test, the breakage was less in the higher wheat temperature range. This is illustrated by the following summary of test results with a grain thrower operating at a belt speed of 4,030 f.p.m. and at a distance of 10 feet from a vertical wood bulkhead:

Wheat kind	Wheat moisture	Mean Breakage		Breakage decrease as percentage of 50° F. values
		50° F. max.	75° F. min.	
	Percent	Percent	Percent	Percent
Spring	10.5-11.5	0.27	0.15	44.5
Winter	10.5-11.5	0.22	0.07	68.2
Spring	12.5-13.5	0.14	0.08	50.0

The amount of breakage occurring in yellow corn was many times that occurring in wheat under the same test treatments. The following table compares the average maximum breakage resulting when yellow corn and wheat was discharged through a 12-inch diameter orifice and dropped 100 feet in free fall onto a concrete surface:

Grain 1/	Grain moisture	Breakage per each of 4 replicated test runs			
		1	2	3	4
	Percent	Percent	Percent	Percent	Percent
Corn	12.5-13.5	12.0	13.6	10.6	7.8
Winter wheat	10.5-11.5	0.2	0.2	0.1	0.1

1/ Same grain at 50° F. used for each replicated test run.

Tests conducted to date indicate that the diameter of the grain discharge orifice, and thus the size of the falling grain stream, has an effect on the amount of breakage occurring during free fall. The following table compares the breakage of yellow corn with soybeans resulting from discharging them through a 12-inch and an 8-inch diameter orifice to fall free 100 feet onto a flat concrete surface:

Grain	Moisture	Temperature	Mean breakage with orifices-		Breakage decrease as percentage of 8-inch orifice values
			8-inch	12-inch	
Corn	12.5-13.5	50 max.	13.8	11.0	20.3
Soybeans	12.5-14.0	40-65	2.2	1.4	35.8
Soybeans	10.5-11.5	40 max.	5.6	2.5	55.1

Tests completed to date indicate that the amount of breakage resulting from handling soybeans is considerably lower than corn but higher than wheat. The maximum breakage in pea beans was 13.65 percent when discharged through an 8-inch diameter orifice and dropped 100 feet in free fall onto a concrete surface. Further tests will be conducted with pea beans to determine handling treatments that will hold the amount of breakage to a desirable minimum.

2. At Manhattan, Kans., laboratory analyses were continued to determine the initial quality of grain samples obtained in tests conducted by Cargill, Inc. under a research contract. Each analysis included determinations of percent of internal kernel cracks, bulk and true density, porosity, percent broken by sieve operation and susceptibility to breakage. Representative samples of wheat were divided and tested for breakage both at Manhattan and Beltsville. Statistical analysis of the data indicated the results obtained at the two laboratories were not comparable.

Results of a study of the effect of moisture content on the bulk density of Hard Red Winter Wheat showed that drying or wetting the wheat had little effect on its bulk density. However the amount of dry matter varied linearly with moisture content.

Two varieties of Hard Red Winter Wheat at 9.1 to 10.5 percent moisture content were tested for internal damage that occurred prior to harvest. From 0 to 37 percent of the kernels from field handcut samples were damaged, compared to from 1 to 55 percent of the kernels harvested by combine. Analysis of results showed a significant effect of wheat variety, location grown and method of harvesting. Two varieties of grain sorghum ranging from 12 to 16 percent moisture content also were tested in the same manner. Results showed 0 to 3 percent of the kernels examined from handcut samples and 1 to 13 percent of the kernels from combined samples were damaged. Statistical

analysis indicated the method of harvesting and the interaction of variety and location significantly affected the number of kernels with internal damage.

The study on the effect of repeated wetting and drying on the internal cracking of winter wheat was completed. A manuscript covering the study is now being prepared. Analysis of results indicate that, when wetting the wheat to about 20 percent moisture content then drying it to 12 percent using various air temperatures, increasing the number of cycles increased the number of multiple cracks but decreased the number of single cracks in the wheat. Although increasing the temperature increased the number of internally cracked kernels, this effect was less pronounced than the effect of the number of drying cycles.

#### E. Dynamic and Static Pressure Phenomena in Grain Under Storage Conditions

At St. Louis, Mo., investigations on the basic theory of dynamic and static pressure phenomena in grain under storage conditions are being conducted under a research contract with Dr. Joel D. Isaacson. Theoretical analysis, applied mathematics, analytical mechanics, and mathematical models are being used to provide a better understanding of grain pressure phenomena, to develop more logical approaches and methods for calculating such pressures, and to formulate specific recommendations for much broader studies of actual pressures and loads occurring in full-scale storage facilities.

A comprehensive literature survey containing more than 100 entries has been completed. The survey includes material published between the years 1883 and 1966, on a worldwide basis. Some 20 factors affecting grain pressures in storage structures have been classified into four main categories as follows: Grain characteristics, bin characteristics, state of the system, and environmental effects.

The investigation and development of mathematical models of pressure mechanisms of the grain storage system are underway. Included are analytic, algebraic, numerical, and topological models. Analytic models are being investigated in terms of ordinary differential and partial differential equations. Initial results with algebraic models show that the model satisfactorily predicts lateral grain pressures for normal values of parameters. Topological model work is underway on the theory of grain-pile transformations. A complete library (51 programs consisting of more than 6,000 IBM cards) has been acquired, edited, compiled and made compatible with an available computer system. This combined system makes it feasible to obtain unique results related to the mechanism of grain-pile transformations. Although the programming and direct use of computers is greater than was anticipated, the progress of the investigations is being facilitated.

#### F. Handling Cotton Bales and Humidifying Storage Compartments

1. Handling. At Bakersfield, Calif., studies were concluded on improving the unit loads of compressed bales carried by 6,000, 10,000, and 18,000 pound clamp trucks. In the conventional method, compressed bales were stacked 2-high

onhead in unit loads of 6, 10, and 12 bales. When clamp trucks picked up the unit load, the top tier of bales had a tendency to tumble and fall to the ground. In the improved method, bales were stacked one-high onhead, and 2 or 3, and sometimes 4, tiers were placed on top in a horizontal position. This rearrangement increased the unit load for the 6,000 pound trucks from 6 to 11 bales, for the 10,000 pound trucks from 10 to 17 bales, and for the 18,000 pound clamp truck 12 to 22 bales. Productive time necessary to move unit loads to a shipping platform also was reduced. Based on 100 bales this time was reduced, using the 6,000-pound clamp truck, from 113 to 92 man-minutes; using the 10,000-pound clamp truck, from 102 to 77 man-minutes; and using 18,000-pound clamp truck from 97 to 62 man-minutes.

Studies were made to compare the use of a low-mast (69-inch) free-lift clamp truck with the standard high-mast truck commonly used. Unlike the low-mast, the top of a standard-mast moves upward when the bale load is raised, which requires care in loading boxcars and closed trucks. Results showed that using the low-lift trucks reduced the time to load a semitrailer truck by 23 man-minutes and to load a boxcar by 16 man-minutes.

A study was initiated to compare leasing with ownership of clamp trucks. Results thus far indicate maintenance of the trucks is an important factor in each case. A truck operated for 1 year (2,000 hours) required 40 hours of downtime for maintenance while a truck operated for 3 years (4,000 to 6,000 hours) required over 800 hours of downtime. Over the same period the operating efficiency of the truck can be expected to decrease 35 percent.

A study has been initiated to develop layouts for storing compressed bales in all-metal, clear-span storage compartments. Recent rulings by insurance rating bureaus now permit, at no increase in cost of premiums, 36,000 instead of 30,000 square feet of floor space to be sprinkled for fire protection in this type compartment. Also, an increase in eave height to 18 feet and ridge height to 33 feet is now permissible.

## 2. Humidifying Storage Compartments

At Bakersfield, Calif., full-scale and pilot-scale studies on maintaining the moisture content of stored cotton at desired levels by humidification continued for the third storage season. The amount and rate of change in moisture content was evaluated for flat, gin-standard density, compress-standard density, and gin high-density bales stored in cordwood blocks, tiered rows and single rows. Results indicate humidified bales increased and remained above the desired 7 percent moisture content. Interior bales in a stack required 2 to 4 weeks longer to reach this moisture content than bales in a single row. Spinning qualities of compress standard-density bales stored in pilot, humidified, and nonhumidified compartments for periods of 6, 15, and 24 months were evaluated by Market Quality Research Division. Results show neither humidity level nor storage time significantly affected the spinning qualities of cotton. However, both humidity level and storage longer than 24 months affected the color grade of cotton.

Engineering design data obtained from full- and pilot-scale humidification studies show that: (1) A pneumatic atomizer broke up water into 50-100 micron-size particles, enough to support 65 percent relative humidity, (2) the minimum distance between an atomizer and bale of cotton was 5 feet, (3) average infiltration of outdoor air caused an air change less than one-half the compartment volume with doors closed and up to 5 air changes with doors open, (4) maintenance required was 8 man-hours each day for all atomizers in 35 cotton compartments, and (5) filtering the water supply, adding solvent or softening the water used for humidification did not reduce the necessary system maintenance.

A manuscript "Moisture Regain in Jute Bagging" was completed and submitted for review. Based on test results, a change in relative humidity causes little change in the weight of jute bagging.

#### G. Aeration and Storage of Cottonseed

At Stoneville, Miss., cottonseed aeration studies were continued in selected commercial storages during the 1966-67 storage season with both improved and existing systems. During the storage period quality and germination were maintained by uniform cooling of the cottonseed with a minimum of fan operation. Modifying the unloading tunnel in a storage for use as an aeration duct has proven satisfactory for uniform cooling and maintenance of quality and germination of the cottonseed during storage. In this storage 750 tons of cottonseed were cooled using a 7 1/2 horsepower motor and blower. Considerably less fan running time was necessary than with the original system which used a 75 horsepower motor. Minor changes in a third storage such as raising the pallets 2-inches higher above the floor, and covering the tunnel with sheet plastic to eliminate short-circuiting of air, improved the effectiveness of the presently used system. Cottonseed quality and germination were maintained during the storage period. Better airflow distribution and more uniform cooling was accomplished with considerably reduced fan running time.

Studies were continued and additional modifications made in a 14,000-ton Muskogee-type storage where cottonseed depths varied from 12 to 75 feet. Better airflow distribution was obtained by sealing the unloading tunnel side-walls for 30 feet from each end. Temperatures recorded in the cottonseed mass indicated adequate cooling in all but a conical area extending downward from the peak of the pile 50 to 60 feet. Here temperatures remained 25 degrees higher than the lowest average temperature (45 degrees). Studies will continue to improve the aeration system to adequately cool all areas of this type storage.

Work continued under a research cooperative agreement with the Texas Engineering Experiment Station, College Station, Tex., to further improve and test an instrument (probe) for determining the "permeability" characteristics of stored cottonseed. At Tunica, Miss., 320 readings from 8 probings were made to depths of 75 feet in a large Muskogee-type storage. These readings were taken in three dimensions in one quadrant of the storage. Analogs were

constructed in the laboratory to locate equal pressure and airflow lines. Comparisons will be made between field data and analog data to determine the feasibility of using analogs to simulate aeration of cottonseed storages.

Work continued under a research cooperative agreement with the Mississippi Agricultural Experiment Station, State College, Miss., and the Market Quality Research Division to determine the effects of aeration and storage environment on the fungus flora on, and in, cottonseed. Acid delinted cottonseed (both high and low moisture contents and high and low quality) was used in these tests. Results of both small-scale and full-scale studies using various treatments of storage temperature, airflow rate, and moisture content showed the low initial germination of high moisture seed dropped to near zero during the test. High concentrations of aflatoxins B1, B2, and G1 were chromatographically obtained from the mid-storage samples of high moisture seed with highest concentrations associated with highest aeration airflow rates and lowest concentrations associated with no aeration. Numerous colonies of species of Aspergillus were obtained.

#### H. Handling Tobacco in Warehouses and Storage of Unprocessed Tobacco

1. At Raleigh, N. C., an experimental tobacco handling system for use on sales floors was tested under actual commercial operating conditions each day of the tobacco marketing season at Carolina Warehouse in Fuquay-Varina, N. C. The system included equipment and procedures for receiving, storing, grading, selling and loading out tobacco.

Single-line, gravity-roller conveyors were installed to move baskets of tobacco from the truck unloading area across an elevated floor scale to a pickup station. The conveyors, using 2 1/2-inch diameter rollers on 4-inch centers, were sloped 1/2-inch per foot in direction of travel except for the level section on the scale platform. About 48 inches of conveyor space was needed for each 42-inch basket of tobacco. Each basket rolled by gravity from the farmer's truck to the scale where it was weighed and records prepared in the normal manner. After weighing, the basket moved on a 90-degree curved conveyor to a pickup station where it was moved by forklift truck to temporary storage on the warehouse floor.

Shortly before the sale individual baskets were placed by forklift truck on a gravity-roller conveyor line that extended through a grading room equipped with artificial daylight, where the tobacco was graded, directly into a sales room equipped with daylight grading lights, comfort air conditioning, and a variable-speed belt conveyor with a range of 180 to 800 baskets per hour. A single-line, gravity-roller conveyor was installed from the sales room to the load out area. The load out operation was planned so that after one basket automatically rolled onto a jack (dolly), a second basket was to be manually placed atop the first. As labor was not available during the 1966 selling season, an alternative method was used whereby the conveyor line beyond the sales room was extended to hold 50 baskets. Seven hundred and eighteen baskets of tobacco marketed by 33 farmers were sold through the system. Spillage of

looseleaf tobacco handled through the system totaled only 0.4 percent. Tobacco sold through the experimental system averaged 67.9 cents per pound compared with the Fuquay market average of 66.7 cents for the same grades.

2. Under a research cooperative agreement with North Carolina Agricultural Experiment Station, "green" unprocessed tobacco was placed under storage at Oxford, N. C. in November 1966 in a packhouse simulating typical storage conditions for "hold over" tobacco. Seven lots of flue-cured tobacco, each weighing approximately 100 pounds, representing cured tobacco harvested from top to bottom of the plant were placed in storage to begin a hold over period from one marketing season to the next. Official Federal grades were placed on each lot, then the lots segregated by moisture content ranging from a low of 14 percent to a high of 24 percent. After 8 months' storage, no spoilage has occurred in the lots having a high moisture content nor has an insect infestation been observed. However, condensation occurred at intervals on the inside of the polyethylene film which caused a "crusty" condition on a thin layer of the adjacent tobacco. No off color, off aroma, or spoilage has occurred.

#### I. Uniform Blending of Seed

At State College, Miss., under a research cooperative agreement with Mississippi Agricultural Experiment Station, the study was continued on uniformly blending seed lots. Clear plastic bins 4 ft. by 4 ft. by 8 ft. high, were constructed to individually test 5 different static blending devices. In the bin unloading operation, the device causes material to flow from various portions of the bin, thus causing blending of the material at the point of discharge. Initial tests were conducted using vari-colored plastic pallets to study the blending action. Analysis of samples is aided by the use of an electronic color sorter. Results of the initial test show adequate mixing is obtained only during the time required to unload one-half the bins. Further tests are now in progress.

#### PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

##### Grain Aeration and Drying

Converse, H. H. 1967. ARS 52-20. A Two-Fan Crossflow Ventilation System for Upright Grain Storages.

Thompson, R. A. 1967. Dryeration and Aeration as Methods of Shelled Corn Preservation. Paper presented at Annual Grain Conditioning Conference, Urbana, Illinois.

Thompson, Thomas L. 1967. Predicted Performances and Optimal Designs of Convection Grain Dryers. Ph.D. Thesis, Purdue University.

Thompson, T. L., Peart, R. M., and Foster, G. H. 1967. Mathematical Simulation of Corn Drying - A New Model. Paper No. 67-313, American Society of Agricultural Engineers.

Shelling Handling, Drying, Aerating and Storing Peanuts

Hutchison, R. S. 1966. Research Studies in Drying Farmers Stock Peanuts. Proceedings, Fourth National Peanut Research Conference, Tifton, Ga.

Davidson, J. I. 1966. Some Performance Characteristics of Conventional Peanut Shellers. Proceedings, Fourth National Peanut Conference, Tifton, Ga.

Handling, Drying and Storing Rice

Louvier, F. J. and Calderwood, D. L. 1967. Breakage of Milled Rice at Different Free Fall Heights. Paper presented at annual meeting of the Southwest Region of the American Society of Agricultural Engineers, Stillwater, Okla.

Calderwood, D. L. and Louvier, F. J. 1967. Rice Drying, Storage, and Handling. The Rice Journal, Annual Issue.

Aeration and Storage of Cottonseed

Smith, L. L. 1966. Aeration Studies in Commercial Storage for Planting Cottonseed. Paper presented at Stoneville Certified Cottonseed Growers Meeting, Stoneville, Miss., September 1966.

Smith, L. L. 1967. Cottonseed Storage and Aeration in Commercial Facilities. Mississippi Agricultural Experiment Station, 80th Annual Report for year ending June 30, 1967.

Smith, L. L. 1967. Improved Aeration System Designs Can Improve Storage Conditions in Commercial Cottonseed Facilities. Mississippi Farm Research.

Handling Tobacco in Warehouses and Storage of Unprocessed Tobacco

Graves, A. H. 1967. Tobacco Handling in Warehouse Sales Floors, North Carolina Agricultural Experiment Station, 1966 Annual Report.

#### AREA NO. 4 HORTICULTURAL CROPS - MARKETING FACILITIES, EQUIPMENT AND METHODS

Problem. Returns to producers and prices paid by consumers for horticultural crops are adversely affected by the use of inefficient marketing facilities, equipment and methods. Better work methods, techniques, devices, operating procedures, equipment, and facilities are needed for precooling, conditioning, storing, handling, cleaning, washing, waxing, sorting, sizing and packing potatoes, citrus fruits, deciduous fruits, vegetables, nuts, and other horticultural crops. Such improvements at shipping points would increase the productivity of labor, prolong the storage life of the commodities, reduce bruises and injuries to these products, reduce marketing cost, expand consumption, and reflect greater returns to producers.

#### USDA PROGRAM

This is a continuing long-range research program covering the development of improved work methods, techniques, devices, operating procedures, equipment, and facility designs for precooling, conditioning, storing, handling, cleaning, washing, waxing, sorting, sizing and packing potatoes, citrus fruits, deciduous fruits, vegetables, nuts, and other horticultural crops. Potato research is carried on at the Red River Valley Potato Research Center, East Grand Forks, Minn.; the Potato Handling Research Center, Presque Isle, Me.; a field office at Gainesville, Fla., and the Hyattsville, Md., office; in both laboratory and commercially owned facilities; in cooperation with the North Dakota, Minnesota, Maine, and Florida Agricultural Experiment Stations, the Red River Valley Potato Growers' Association, the Market Quality Research Division, the Agricultural Engineering Research Division, the Eastern Utilization Research and Development Division, the Marketing Economics Division of ERS, and the Forest Products Laboratory of the Forest Service. Citrus fruit research is carried on by field offices at Gainesville, Fla., and Athens, Ga., in cooperation with the Florida Agricultural Experiment Station, the Agricultural Engineering Research Division, the Market Quality Research Division, and commercial packers. Deciduous fruit research is carried on by the Wenatchee, Wash., and Athens, Ga., field offices and by the Hyattsville office; in both laboratory and commercially owned facilities; in cooperation with the Washington and Georgia Agricultural Experiment Stations, and the Market Quality Research Division. In Michigan, research on deciduous fruits is conducted under a research contract with Michigan State University. Vegetable research is conducted by the Gainesville, Fla., and Athens, Ga., field offices, in commercial packing plants and in laboratory facilities of the University of Florida, in cooperation with the Florida and Georgia Agricultural Experiment Stations and with the Market Quality Research Division. Sweetpotato work in North Carolina is conducted under a cooperative agreement with the North Carolina Station. Research on tree nuts is carried on by the Athens, Ga., field

office in both laboratory and commercially owned facilities in cooperation with the Georgia Agricultural Experiment Stations.

The Federal effort devoted to research in this area during the Fiscal Year 1967 totaled 11.9 scientific man-years (2.1 extramural); 4.4 to potatoes (1.1 extramural); 1.4 to citrus fruits; 4.2 to deciduous fruits and nuts (1.0 extramural); 0.9 to vegetables; and 1.0 to program leadership.

#### REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

##### A. Handling, Degreening, and Packing Citrus Fruit

This research, at Gainesville, Fla., is directed toward developing improved methods, devices, equipment, and facilities for conditioning, handling, and packing citrus fruits at shipping points.

Tests on color sorting of oranges prior to degreening, based on plans made jointly by MQRD and TFRD personnel, were completed with the commercial photoelectric sorting machine at the MQRD Orlando Laboratory. Seven biweekly tests were performed. Hamlin oranges were picked and washed, then sorted by the machine into four uniform color groups, and degreened for 96 hours under controlled conditions. Observations were taken on each fruit with the Ratiospect instrument and with visual plaque readings immediately after sorting and again after one, two, three, and four days degreening. These data were taken to obtain a measurement of degreening time for each color class and are now being analyzed statistically.

During the tests, fruit was selected from each color group and measurements made on its internal quality factors. No consistent differences were found for the internal quality factors between the different color sorted groups. Data from decay tests are also being analyzed statistically. In general, after a holding period of three weeks, fruit with 0 or 1 day degreening had 10 percent decay, fruit with 2 days degreening had 22 percent decay, and fruit with 3 or 4 days degreening had 30 to 35 percent decay.

Additional tests of color sorting of citrus were made to determine the effect of unwashed fruit on the accuracy of the photoelectric color sorting machine. Hamlin, Valencia, and Temple oranges, and limes were sorted by the machine into four fairly uniform color groups. Readings also were taken on the limes and Temple oranges with the Ratiospect instrument. A test also was made to determine the effect of washing oranges prior to degreening on the subsequent degreening rate.

Color slides were made of representative color sorted groups and a movie was made of the operation of the machine while sorting oranges.

Information to be used in developing comparative cost relationships between color class degreening and the present degreening method was obtained from several citrus packinghouses.

A presentation of the color sorting research made during a meeting of the Florida Fresh Citrus Shippers' Association included a demonstration of the photoelectric sorting machine, an outline of the research, and a display of samples of the various color sorts obtained for degreening and uniformity of color. The group responded very favorably and expressed considerable interest in the research.

In accordance with the interests of the Automation Committee of the Florida Fresh Citrus Shippers' Association, studies were made by regular time study and micromotion movies to evaluate new semiautomatic equipment both for filling consumer-size bags (5- and 8-pound) and for filling cartons and crates.

Preliminary findings showed the productivity for the machine-assisted place packing as only about 5 percent better than for the established manual roll-board method of filling cartons and crates. On the filling of small bags, however, the indicated saving in labor was about 40 percent over the manual roll-board method. The possibility of relatively low equipment utilization with the application of semiautomatic machinery was clearly shown from the studies. Bag-filling machines operated during only 26 percent of the cycle at a bag-filling station. However, when fruit was bagged at a central station, rather than at individual bag-filling stations, the operating time of the bag-filling machine increased to 38 percent of the complete cycle time and the number of filling stations was reduced under given conditions from 10 to 6. With fewer stations, the investment in filling equipment would be lowered from \$3,000 to \$5,000, taking as a base 10 bag-filling stations with semiautomatic machines and master cartoning done at each filling station. Labor requirements would remain essentially the same. On the filling of 4/5-bushel cartons, preliminary data showed that one shaker-pack station (output rate 260 cartons per hour of 252-size oranges) would be equivalent to the combined output rate of six of the semiautomatic machines having one worker at each machine. Work to automatically master carton fruit packed in small bags involved construction of an experimental channel-type bagger unit having variations to make it a dual purpose unit for machine-assisted place packing of fruit in cartons and for the filling of small bags.

To explore the possibilities of ultrasonic cleaning of citrus fruit, samples of dirty oranges were sent to two equipment manufacturers for cleaning tests. Although one company indicated it was unable to obtain satisfactory cleaning action, the second company stated that its tests of the equipment worked quite well in cleaning the fruit. Arrangements have been made to bring equipment to Gainesville for performing tests.

In collaboration with the Florida Extension Service Agricultural Engineers, a layout for a new avocado-lime-mango packinghouse was developed for a Homestead, Fla., firm.

An analysis of volume-capacity relationships between pallet boxes and the standard field box was completed. Experiments involving both scale model field boxes and pallet boxes, using marbles to represent oranges, and full-size field and pallet boxes, using real fruit, were conducted to provide data for a draft of a tentative addition to or a revision of the Florida Citrus Code specifying volume of a pallet box to provide 10 field-box capacity. This report, based on the work of a committee of three representing, respectively, the Transportation and Facilities Research Division, ARS, the Agricultural Engineering Research Division, ARS, and the Lake Alfred Citrus Experiment Station, was completed and submitted to the Florida Citrus Commission for its consideration and final disposition. The tentative proposed addition to or revision of the Florida Citrus Code reads as follows: "A container of capacity equivalent to 10 standard field boxes shall have external dimension not to exceed 32 inches in overall height nor 46 inches in overall width and an internal volume to be filled with fruit of 43,500 cubic inches. Such containers for fresh fruit use should provide a headspace above the fruit of at least 2 inches to minimize fruit damage and to facilitate stacking and degreening. When a headspace is used, the level equivalent to 43,500 cubic inches shall be clearly marked inside the container on all four sides or all four corners. Any containers that differ from 43,500 cubic inches net internal volume shall be referred to the Commissioner of Agriculture for a ruling as to net contents in terms of field boxes. Such net contents shall be clearly marked on the outside of the container in letters and digits at least 2 inches high."

Work on an evaluation of handling systems for citrus fruit involving field boxes, pallet boxes, full bulk, and modified bulk was continued. Time study and other data were further processed and used in developing cycle times, including all steps between the picker and the packing line, on which to base the labor and equipment input for various combinations of equipment, quantities of fruit per load and distances between the points involved. Approximately 70 percent of the derivation of input requirement base values was completed and some of the computations for number of workers and units of equipment required at different levels of production per week were also completed.

#### B. Handling and Packing Deciduous Fruits

This research is directed toward the development of more efficient work methods and equipment for handling, washing, sorting, sizing and packing apples and peaches. It includes studies on the impact of electronic color sorting of apples on related packinghouse operations, an evaluation of pre-sizing and presorting apples in commercial storages and packinghouses, and the development of new equipment for prestorage sorting and sizing of apples.

1. At Wenatchee, Wash., tests were conducted with the experimental unitized brush-roll sorting and sizing line to determine if it reduced fruit damage over that in conventional grading lines, and how well it brushed and sized apples. These tests showed that fruit damage was greatly reduced and brushing

was satisfactory. However, a final decision could not be made regarding sizing accuracy. Tests with presized apples indicated that uniform density of the brushing material was more important than first thought. The original brush material on the rolls lacked the necessary uniformity for accurate sizing, and, consequently, was replaced. This change corrected the major source of sizing errors. Subsequent tests showed that some fruit was still being mis-sized, and these sizing errors were traced to the failure of some brushes to maintain a constant rate of rotation during the sizing operation. The slowing of the rotation rate was due to a lack of a positive drive which was corrected by repositioning the drive belt, straightening brush shafts that had been sprung, and replacing damaged pulleys. Tests made after these modifications with small lots of fruit indicate that the sizing problem has been solved.

If commercial tests during the 1967-68 season confirm preliminary findings, the unitized line will permit packinghouse operators the option of prestorage sorting and sizing of fruit. In addition, this equipment is expected to be as effective for peaches and pears (and perhaps other fruits and vegetables) as it is for apples; thus providing a versatility that does not exist with currently available equipment.

Preliminary sketches were prepared of an overhead accumulator for fruit from packing belts which may eliminate many of the problems associated with existing return-flow belt systems.

Work on electronic color sorting of apples was devoted exclusively to preparing a manuscript, "An Evaluation of Electronic Color Sorting." This report outlines the effects of color sorting on plant layout, other packing line operations, costs and savings associated with electronic color sorting, accuracy of sorting, and bruising of fruit. The analysis is based on annual volumes of 100,000, 200,000, and 500,000 packed boxes. This report will give packinghouse managers concrete means for evaluating a color sorting operation in their own plants, while avoiding the cost that would be involved in actually installing and using the machine.

2. At East Lansing, Mich., research was continued under a research contract with Michigan State University on designing, constructing and testing a hydrohandling system for prestorage sorting and sizing of apples. Construction of the prototype system was completed and it was installed at a commercial apple packing and storage house at Belding, Mich., for test purposes.

During the 1966 harvest, sustained runs of the prototype hydrohandling system were made with roughly 30,000 bushels of orchard-run apples received in pallet boxes of approximately 20-bushel capacity, sorted, sized, and filled back into pallet boxes. Several different varieties of fruit were used.

Based on the preliminary evaluation of the data and findings from the test runs, the contract for this research was amended to provide for the redesign of and/or additions to some of the components of the system. Working

drawings and a report describing the proposed changes had been accepted by the Department at the end of the year.

During this report period, a movie which was made primarily for record purposes was shown to at least ten industry audiences, ranging from 25 to 250 people. Also, several papers were presented to groups throughout the United States.

3. At Athens, Ga., work was continued on a project whose long-range objective is to reduce the costs of marketing fresh peaches by developing improved handling systems that incorporate the most effective utilization of labor and equipment. Emphasis was placed on grading, filling, and box makeup and supply operations. Time studies were made in five commercial peach packing-houses in Georgia and South Carolina to measure labor and equipment requirements for existing methods of performing these operations at different volume levels. Data were analyzed, compiled, and filed for future use.

A study to determine the economic feasibility of handling peaches in pallet boxes was completed. A pallet box dumper developed by an equipment manufacturer and installed in a South Carolina peach packinghouse was evaluated under commercial operating conditions. Labor and equipment requirements for the basic operations associated with pallet box handling were determined. Labor and equipment data for the field box method, which were available from previous work, were used to compute the labor and equipment costs for handling peaches by each method in a synthesized peach packinghouse operation having the capacity to dump 750 bushels per hour. Labor and equipment costs for the pallet box method were approximately \$0.03 per bushel less than for the field box method. This research also showed that peaches can be handled in pallet boxes with no more injury than in field boxes. Prior to this research no data were available to provide industry with information needed to decide whether or not to shift to pallet boxes. A manuscript, "Handling Peaches in Pallet Boxes," which is in draft form, should provide packinghouse operators the necessary decision-making data.

Additional data were obtained to compare the cost of precooling peaches in bulk hydrocoolers with that for flood-type hydrocoolers. Results of this study will aid packers in selecting hydrocooling systems that will perform efficiently and economically.

#### C. Handling and Packing Potatoes

1. Presque Isle, Me. Research under this project is directed toward reducing operating costs of potato storages and packinghouses by increasing the productivity of labor employed and reducing losses from bruises and mechanical injuries in handling, storing, cleaning, grading, sizing and packing potatoes. It involves the development of more efficient work methods, operating procedures, equipment, and facilities for handling, storing, and preparing for market Maine potatoes.

During the report period, research was carried on by the Maine Agricultural Experiment Station under research cooperative agreements. Intramural work was limited because the vacancy for this one-man field office was not filled until late in the report period.

Joint work was continued on the preparation of a manuscript, "Supplying the Packing Line with Potatoes in Maine Storages at Rates of 200 Hundredweight Per Hour and Above."

Under a research cooperative agreement, the Maine Agricultural Experiment Station continued work on the design and construction of an improved sizer for "long" white potatoes. Analysis of previously collected data revealed that a definite relationship exists between either height or length, and weight for all "long white" varieties. This information provided design data for the new sizer and indicated possibilities for modification of existing sizers once the magnitude of the relationships is determined.

As potatoes of a uniform size rather than weight are desired for market, the improved sizer was designed to size either by one or two dimensions. To insure that the potato's height will be used as one of the sizing criteria, the machine is designed to rotate the tubers at least twice in each size area or zone. To increase accuracy of the machine, the sizing devices are set to open a maximum of 40 millimeters at the rate of 6 millimeters per size range. In addition to the elimination of cull potatoes of less than 40 millimeters minimum dimension, provisions were made for sizing five marketable groups. Oversize potatoes comprise the seventh degree of separation.

The devices that accomplished the sizing are split spools. The machine sizes in much the same manner as an expanding-roll sizer in that a potato is supported by adjacent spools until the separating spools allow it to drop through the rolls onto a conveyor. However, an expanding-roll sizer expands in one direction only, whereas the split spools expand in two directions. Rotation assures that the potato is sized on the basis of height; lateral expansion on the basis of length.

Initial testing involved placing individual presized potatoes on the spools and observing if they were sized correctly. Adjustments were made to obtain four size categories. Next, potatoes were placed on the machine in larger groups to observe how this affected the operation.

Results of the test runs for the one-dimensional phase of the testing indicated that the most accurate sizing took place in the 40 to 55 millimeter group where 94 percent of the tubers were correctly sized. The lower percentage for correctly sized potatoes in the other size categories can be attributed to poor potato rotation due to spool slippage and to greater dimensional variations in the larger potatoes. This is substantiated by the percentage of undersized potatoes in each category which were sized on width instead of height, and were, therefore, placed in the next larger size

category. By appearance, the potatoes in each size category were sized uniformly.

During these tests, the total lateral expansion was set at a maximum of 76 millimeters. As the sample potatoes were considerably shorter than normal, the rate of lateral expansion was adjusted to maximums of 133, 138, 141, and 152 millimeters on conveyors one through four respectively. Mean lengths were reduced in size categories one, two, and four in comparison made to the one-dimensional test.

In the two-dimensional tests on the height basis, the machine sized about the same percentage correctly as in the previous tests. However, on the length basis alone, the percentage sized correctly was lower in size categories three and four; caused by potatoes that are heavier on one end tipping before falling through the spools. In a sample containing many extremely long potatoes, it is more likely that an even greater increase in the sizing accuracy would have been observed. However, the potatoes appeared uniformly sized.

Over two-thirds of the potatoes were correctly sized with a high of 100 percent being sized correctly in one category. Most of the error in sizing was caused by the width being incorrectly used as a sizing criterion. Improved potato rotation will assure that the correct dimensions are presented to the sizing spools. In every instance, each category of potatoes appeared to be uniformly sized. The results of future commercial testing should be useful in the modification of existing sizers as well as in the construction of new machines.

Under a second cooperative agreement, the Maine Agricultural Experiment Station initiated research on hydraulic handling systems for potatoes, sugar beets, and other crops.

Fluming trials were conducted in an 80-foot trapezoidal flume having an 8-inch bottom width, 15-inch top width and 14-inch depth. Three flume slopes, two rates of water flow, and two potato varieties in increments of 170 pounds per minute up to the maximum which could be handled without excessive over-flow of the supply tanks were used.

Based on preliminary data, it appears that the minimum water--potato rate for Kennebecs (round whites) is about 5 to 1 and for Russet Burbanks (long whites) about 7 to 1. One inch in 15 feet appears to be the most desirable flume slope for flume lengths up to 80 feet. A slope of 1 inch in 12 feet is satisfactory if high potato rates are needed. If low potato rates are anticipated, velocities can be reduced by using a slope of 1 inch in 18 feet. At low potato rates (170 pounds per minute) velocities of from 240 to 265 feet per minute occur even on the lower slope.

To evaluate the effect of water pressure on disease development in subsequent storage, levels of 0, 5, 10, 15, 20, and 46 feet were used with both tap water and water from a flume pit. Only the 20-foot level resulted in a significant increase in lenticel infection. However, there was a proportional non-significant increase at the lower levels. No breakdown occurred in storage.

In connection with studies on sump clean out and waste disposal from flumes, soil samples were collected from potato processing plants ahead of the flumes and in the sump area following fluming where the suspended material was allowed to settle out of the effluent. Various amounts of vegetative material were found in the samples both before and after fluming.

A series of permeability measurements were made on material from the total sample as well as on the soil separates for each sample at various densities. Measurements were also made to determine the effect of a series of wetting and drying cycles on the permeability and also on the effect of adding layers of soil slurry on the top of a dried sample to simulate the effects of re-changing a disposal area. The calculations have not yet been completed for the permeability measurements.

Results of mechanical analyses on the various samples indicate that the grain-size distributions are similar for samples collected prior to and after fluming. The standard hydrometer method was used in making the mechanical analyses. A second series of mechanical analyses were made without a deflocculating agent to determine the effect of this agent on the vegetative matter. Results of this comparison are inconclusive.

A Torvane shear tester was used in determining the variation of shear strength with moisture content for the various samples. This series of tests on each sample started with a slurry (170% moisture) and continued through an air dry condition (105° F. air blowing over the sample). Two samples containing considerable vegetable matter resulted in higher shear strength at high moisture content. Preliminary indications are that this was due to the type and amount of vegetation in the sample. Considerable shrinkage and cracking during drying was noted in all samples.

A device for determining apparent viscosity of the fluming liquid was designed and constructed. It consists of 50 feet of 1-inch copper tubing coiled in a 2-foot diameter circle with instrumentation installed to measure the head loss across the total length of pipe. The associated plumbing includes a sump, the tank, pump, and valves. Preliminary tests indicate that the device should provide the desired information on the hydraulic characteristics of fluming liquids.

A 10-inch experimental pipeline system was installed on the University campus. A model system was also constructed and tested to evaluate the possibilities for solid injection by the jet pump configuration used.

2. Gainesville, Fla. Research objectives at this location are the development of more efficient work methods, operating procedures, and equipment for the handling and preparation for market of potatoes in spring-crop areas.

Work by the Gainesville office during the report year was limited to the preparation of an outline on "Possible Areas of Application of Research Effort--Potato Handling and Packing" which was discussed with a cooperative in the Hastings, Fla., area to obtain a better understanding of the needs of the potato industry and facilitate a more effective use of research resources during future years.

3. Red River Valley Potato Research Center, East Grand Forks, Minn. Work is directed toward developing more efficient work methods, techniques, devices, and equipment for the handling and preparation for market of midwestern fall-crop potatoes.

Writing of the manuscript "Handling Potatoes from Storage to the Packing Line" was completed. This report analyzes costs of handling potatoes from storage bins to the packing line in 42,000 cwt., 60,000 cwt., and 120,000 cwt. storages of multiple door, cross-alley, and deep bin types by fluming, forking to conveyors, and bulk scooping systems at handling rates of 100, 200, and 300 cwt. per hours.

The initial methods for analyses of handling seed and processing potatoes have been set up. Bulk scooping will be emphasized and the effects of storage size, scoop size and speed, storage layout, and grading line location on the performance of the handling operation will be determined.

Preliminary analyses were made of the problems associated with bulk dumping from farm trucks at the storage. Several possible solutions in the form of methods and equipment changes were considered. However, the problems are such that much additional work would be required for development of any of the systems.

A general outline was prepared for a report covering the research on the impact of cleaning and sizing fall-crop potatoes before storage on handling, storage, and packing. To substantiate earlier results, a selected sample of potatoes were manually sized with fruit rings and an array of cylinders of the same diameters as the fruit rings. Neither the cylinders or rings were found to be more accurate or to eliminate human error. A rapid manual means for accurate size checking of commercial sizers is still needed. An analysis of length, width, volume, weight, and changes during storage was made on small lots of potatoes. Linear logarithmic relationships of weight to length and width were found to correlate very well ( $r= .93$  to  $.99$ ). These results are similar to those reported earlier for Maine, but for different varieties. Actual change in weight correlated well ( $r= .87$  to  $.99$ ) with change in length. On the basis of percent change of initial weight and percent change of initial length, correlation was poor ( $r= .34$  to  $.68$ ). Actual change in weight did not correlate well with actual change in width

( $r = .24$  to  $.54$ ). Potato volume was calculated using length, width, and thickness measurements. Using the equation for the volume of an ellipsoid gave the most accurate results. Calculated volume was within -5 percent to -10 percent of the true tuber volume. The equation for the volume of a spheroid was also used. None of these gave as consistent or as accurate results as were obtained with the ellipsoid equation. Actual tuber volume was determined by weight in air and weight in water specific gravity technique. This was more accurate than determining volume by water displacement. These data were collected for three different size tubers of the Kennebec, Norgold Russett and La Rouge varieties.

#### D. Handling and Packing Vegetables

At Gainesville, Fla., this research has as its objective the development of improved work methods, devices, and operational procedures for the handling and preparation for market of vegetables at Florida shipping points.

Field testing of equipment to mechanically size celery stalks by weight was completed and a manuscript was drafted covering this research. The manuscript, "Size Celery Stalks by Weight with an Electronic Scale," describes tests conducted on a small package electronic checkweigher scale to determine the feasibility of separating celery stalks by weight. This scale, which will weigh stalks at a rate of approximately 200 per minute, was compared with a mechanical beam-type scale operating at a rate of 90 stalks per minute and with the subjective hand sizing method which is in universal use.

Data developed during the year indicate a scale accuracy of  $\pm 0.065$  pounds for the electronic scale and  $\pm 0.088$  pounds for the beam-type scale when the mean stalk weight was approximately 2 pounds. When workers subjectively estimate stalk size, which is commonly done when celery is packed in the field, about 33 percent of the stalks were misclassified.

Although it was found that the electronic scale was highly accurate at a stalk rate of 200 per minute, the spacing of stalks as they travel across the scale is very critical. The scale always misclassified the second stalk if there were 8 inches or less clear space between it and the preceding stalk. When stalks were located on the feed belt with 9 inches clear space between them, they could be weighed at 200 stalks per minute with a 3 percent weigh error caused by close spacing. At this rate of handling stalks, the belt on the weigh scale should operate at 426 feet per minute and the feed belt at 416 feet per minute.

Another manuscript entitled "Design for a Celery Packinghouse" was prepared. This manuscript describes a system for mechanical harvesting of celery based on design principles for a harvester established by the Florida Agricultural Experiment Station, hauling celery in bulk in pallet boxes to the packinghouse, mechanical weigh sizing of celery stalks, and manual place packing celery stalks into crates at work stations of improved design. Labor, equipment, and facility costs are established and compared with the cost to

manually harvest and pack celery in the field. The final system design will require 30 percent fewer workers than the manual field harvesting and packing system. Labor cost to mechanically harvest and pack celery in a packinghouse is 26.7 cents per crate as compared to 49.8 cents per crate for the manual harvest and field packing method.

At least one celery and sweet corn grower has constructed a packinghouse incorporating the ideas developed in the course of this research. This packinghouse reduced labor requirements from 0.24 man-hours by conventional methods to 0.14 man-hours per crate. It appears that acceptance of these methods will become general for the industry.

Three prototypes of an experimental celery packing stand were constructed and tested in a commercial packinghouse. The packing stands were of the folding type which, when activated by the worker, lowered the packed crate to a conveyor located directly in front of the stand and beneath the incoming stalk conveyor. Tests conducted during the first month of operation while the packers were unaccustomed to the equipment and methods required to pack celery in a central packinghouse (the packers had a tendency to subjectively size the celery stalks as was common in the field packing system), achieved a packing rate of approximately 77 crates per man-hour, as compared with the rate of 14 crates per man-hour for the field packing system.

Further work on color sorting of vine-ripened tomatoes with a commercial photoelectric sorting machine was done in cooperation with Market Quality Research Division. Tomatoes were sorted by this machine into four color groups and reflectance and transmittance readings were made with the Ratio-spect instrument immediately after sorting and after 1, 2, and 3 days of ripening. Also, color slides were made daily during the ripening period. The data are now being analyzed by computer. In general, the tomatoes were sorted quite well. However, it was difficult to consistently sort tomatoes showing a slight color break from those that were entirely green in color.

Feasibility studies of color sorting in commercial packinghouses indicate that the main problems to be resolved are methods of conveying the fruit through the viewing chamber and channeling the fruit into the correct color group. Also to be resolved is the desirability of separating the fruit into several color groups at a central location vs. decentralizing the color sort operation and separating color groups from the main flow of tomatoes at different locations.

With presently available commercial color sorting equipment, the object to be sorted is viewed at only two or three points and the light reflected from all points is averaged together. Work has been done on initial steps to develop new equipment which would be better adapted to sorting certain fruits and vegetables for color and also for surface defects. The object would be viewed at several equidistant points, and sorting would be based on consideration of the reflected light from each point rather than by averaging the reflectance from all viewed points. Such equipment would have the

capabilities of sorting products with a considerable variation in color on a single object or, if enough small points were viewed, it could sort products with very small surface defects. Because of the difficulties in viewing more than two or three points on an object by use of conventional optical systems, the use of fiber optics units for viewing several points has been considered. Solid state photoconductive cells have been considered for use as photo-electric sensing devices because of their inherent characteristics of ruggedness, low power requirements, and small size. Information on fiber optics equipment has been assembled and suggestions on the use of fiber optics units for this type of equipment were obtained from manufacturers. Also, information on photoconductive cells and information on spectral reflectance curves for citrus and tomatoes have been obtained.

Preliminary data on the labor requirements to grade, color sort, and pack vine-ripened tomatoes showed that the grading labor required varies directly with the quality of the incoming fruit. For average quality fruit (65 percent U.S. No. 1's and 20 to 25 percent U.S. No. 2's) and a dump rate of approximately 1800 tomatoes per hour, 20 to 25 graders will be required on the packing line. Data on wrapping and place packing tomatoes in 8-pound and 20-pound cartons showed that although the packers were generally efficient utilizing the commonly used methods, approximately 75 percent of the total time required is expended during the elements "wrap and place pack." It was also found that the fruit size within a size group varied to the extent that oftentimes one or two extra fruit had to be placed into the carton to assure that the net weight of the packed fruit was equivalent to the weight printed on the carton. The tissue in which the fruit is wrapped serves primarily as a cushion between the tomatoes as they are in transit. Packing times could be reduced by approximately 50 percent if other materials were used to provide this cushioning effect and the tomatoes were not wrapped.

#### E. Storage of Deciduous Fruit

1. Room Cooling Rates. The purposes of the research, at Wenatchee, Wash., are to: (1) Measure and evaluate the cooling rates of fruits stored in shipping containers of designs that should properly protect the fruit, shorten the cooling period, and maintain the fruit at proper storage temperatures; and (2) develop improved handling, stacking, and storage practices.

Cooling studies were continued with packed boxes of apples. A standard fiberboard box of tray-packed apples was used for a comparison or check. One of the test boxes had enlarged vent holes which were increased in size from the standard 1 1/2- by 1/2 inch to 1 1/2- by 1 inch and an additional hole in the center of each end 2 1/2- by 1 inch was added. In the other box tested, special holes were placed in each end. Additional tests were run on the same boxes using Dow plastic nonperforated trays. Analysis of data obtained from tests showed that the check apple box had a half cooling time of 33.2 hours. The box with enlarged holes had a half cooling time of 26.0 hours or an index of 93.5 when compared to the check with an index of 100.

The half cooling time of the box with the special holes was 14.8 hours, and an index of 45.6 when compared to the check. Therefore, the box had a half cooling time less than one-half that of the standard fiberboard boxes now being used commercially.

These tests indicate that the room cooling time of fruit packed in standard fiberboard boxes can be reduced over 50 percent by the addition of enlarged vent holes in the neutral areas of the ends of the boxes. The addition of these holes does not appear to alter the strength of the box to any great extent.

2. Refrigerated Storage. The objectives of the project at Wenatchee, Wash., are to: (1) Investigate airflow distribution methods, patterns, and rates in refrigerated fruit storages to determine and evaluate the influence of these factors on cooling fruit and bringing it to optimum storage temperatures; (2) determine and evaluate heat gain through various structural features of fruit storages and make suggestions for improved designs; (3) redesign storage houses for the most efficient handling and storage of fruit in pallet boxes; and (4) evaluate hydrocooling of apples before they are placed in storage.

Several air doors made by a refrigeration equipment company were checked for airflow pattern. These doors are of the vertical flow nonreturn type and are mounted over the doors of cold storage rooms. All doors checked had satisfactory air velocity and volume. A few small adjustments were made in the angle of the air streams to obtain the best seal on some of the doors.

A paper, "Refrigerated Storages," was prepared for presentation at the Western Regional Plan Exchange Committee Conference at the Oregon State University, Corvallis, Oregon, July 13, 1967. This paper mainly covered the design requirements for refrigerated apple storages.

3. Controlled Atmosphere Storage of Apples. Work on this project at Wenatchee, Wash., is designed to develop improved methods, techniques, equipment, and facilities for the controlled atmosphere (C.A.) storage of apples in the Pacific Northwest, and is in cooperation with the Market Quality Research Division.

Studies were continued on C.A. storages using several different systems to obtain the correct atmospheres for storage. The systems were: Caustic Soda scrubbers, using lime for CO<sub>2</sub> absorption, Desomatic absorber or Molecular Sieve, and Tectrol units, and also a system where Tectrol units are used to pull the rooms down to the desired atmosphere with one of the other methods used as a scrubber for the CO<sub>2</sub>.

This was a year of considerable scald, and scald appeared on the C.A. apples as well as on those in regular storage. This indicates steps should be taken to protect the apples going into C.A. against storage scald the same as for regular storage.

The use of sacks of lime for scrubbing out the CO<sub>2</sub> appears to be favored over the use of caustic soda because of the ease of handling. The use of water for scrubbing out the CO<sub>2</sub> has been discontinued in this area because of the difficulty of obtaining the necessary lower percentage of CO<sub>2</sub>.

F. Storage of Potatoes

Work under this program, at the Red River Valley Potato Research Center, is directed toward providing optimum storage conditions for fall-crop potatoes for table stock, seed, and processing; and developing improved layouts and designs for potato storage houses, which will permit the use of the most efficient handling and packing methods, keep injuries and mechanical damage to a minimum, and minimize construction and maintenance costs.

1. For Table Stock and Seed. Designing, drafting, and the preparation of specifications have been basically completed for a 60,000 cwt. long bin, cross alley potato storage. These will be identified as "Potato Storage--60,000 Cwt. Cross Alley," Plan No. 6018, through the Cooperative Farm Building Plan Exchange. A draft of a manuscript for a Miscellaneous Publication on this plan has been prepared and the art work for this publication is about 75 percent complete.

Designing and drafting on a fourth storage plan is about 75 percent complete. This will be identified as "Potato Storage--25,000 Cwt. Pallet Box" and also will be distributed through the Cooperative Farm Building Plan Exchange. A draft of the specifications for this storage are essentially complete. A manuscript draft was also prepared for a Miscellaneous Publication on this plan.

Full-scale testing of the 20-foot span "slotted" bin fronts was completed in a local storage. Their performance was highly satisfactory. Data gathered from this test have been incorporated as minor design changes to the plans being developed to add versatility to the installations. The "slotted" fronts designed for a storage at Stephen, Minn., have given two full years of satisfactory performance. A third commercial installation of a type of "slotted" front was inspected this year and is performing well.

Work on adaptation of "slotted" fronts to bulk scoop handling equipment was started with the installation at the Red River Valley Potato Research Center of a panel for test purposes. A splice arrangement has also been given an initial test.

The outline for a manuscript entitled "Bin Fronts for Potato Storages" was submitted and approved. Rough draft work on the manuscript is underway. This report will incorporate the results of experimental work on bin fronts and a summarization of bin front problems.

Revision and updating of the "Storage Requirement" section of a fall-crop storage bulletin was completed.

A draft of a revision of AMS-401, "Pressures on Walls of Potato Storage Bins," was prepared for review. This revision will update the report and eliminate some errors of interpretation.

2. For Processing. A third calibration of thermocouple cables and recorders was made in the chip storage bin to obtain a more reliable and accurate temperature history. The system was found to be accurate to within  $\pm 1^{\circ}$  F.

All vapor pressure difference and weight loss data collected in a controlled temperature room have been plotted and regression equations calculated. No consistent patterns were observed.

A limited number of relative humidity readings were taken in a 12-foot deep chip bin that was held at 55° F. and 55 percent relative humidity with through ventilation. Depending on location in the bin, humidity increased from 1/2 to 10 percent from the bottom to the top of the potato pile. Most locations showed a 2 to 3 percent increase.

#### G. Cooling Deciduous Fruits

This research is designed to develop improved methods, equipment, operating practices, and techniques for use in existing or new facilities for more efficient cooling of deciduous fruit.

At Wenatchee, Wash., the project to determine the possible advantages and disadvantages of hydrocooling apples prior to storage was continued. Mature Delicious and Golden Delicious apples were hydrocooled and placed in 30° F. storage. Results show that mature apples hydrocooled to a core temperature of 40° F. and placed in 30° F. storage, and apples cooled to a storage temperature of 32° F. in 3 days and in 7 days have the same storage life expectancy and dessert quality. All samples of apples developed some storage scald. The hydrocooled fruit showed the greatest degree of storage scald.

At Athens, Ga., research carried out by the Georgia Agricultural Experiment Stations under a cooperative agreement utilizes the experimental forced-air precooler reported previously. Objectives are three-fold: (1) To evaluate performance; (2) to investigate cooling effectiveness of apples, strawberries and peaches in relation to system performance; and (3) to develop mathematical expressions of heat transfer with respect to product properties and configurations.

Performance tests demonstrated the need for additional modifications of the precooler to improve the system performance under full-load conditions. For example, the installation of turning vanes and splitters in the air ducts resulted in a 13 percent reduction in fan power requirements and improved distribution of airflow in the system. These tests, using cans of water to simulate product load, revealed a difficulty with high head pressure with the air cooled condensers. This problem was alleviated by the installation of spray nozzles for fog application to the air entering the condenser coils.

Ten pallet boxes, each containing 29 five-pound cans, were cooled from 85° to 65° F. in 30 minutes. Not considering the containers, the load imposed on the system was approximately 60,000 B.t.u./hr. These conditions resulted in a system efficiency of roughly 33 percent. Reduction of head pressure with fog application indicates that the efficiency can be increased substantially.

Eight test runs with strawberries in standard 12-pint flats were conducted to determine the effect of air temperature, air distribution, and stack depth on cooling rate. Berries in single layer flats were cooled from 63° to 31° F. at the top and 53° F. at the bottom of the containers in 30 minutes. Air temperature was 15° F. Air at 25° F. cooled the berries in the top of a single layer from 62° to 32° F. in one hour. When the flats were stacked two deep, the bottom layer cooled very slowly which indicates the need to force air through the berry interstices in the containers rather than permit it to flow over the containers as was the case in these tests. Velocity of air approaching the fruit was approximately 500 ft./min. No dessication or otherwise undesirable appearance was observed.

A draft of a manuscript, "Heat Transfer Properties and Characteristics that Affect the Design of Precooling Systems for Apples," was initiated. The manuscript will report values of thermal conductivity and thermal diffusivity, moisture content, and specific gravity of Red Delicious apples. Temperature distribution during cooling in a well-agitated water bath also will be reported. The report will include results of investigations to evaluate the temperature response of Red Delicious apples in bulk lots when cooled with air flowing through the void spaces of fruit in bulk. Results indicated that apples can be cooled by this method at a rate nearly as fast as by hydro-cooling. The practicality of this method for commercial use remains questionable from the standpoint of economy. Additional studies on an applied scale are needed to further explore this problem.

Temperature response and cooling load calculations were made to ascertain the operating requirements and the refrigeration capacities needed for hydro-cooling peaches in both bulk and flood-type hydrocoolers. Calculations of extraneous heat gain to the hydrocooler under various ambient conditions, including insulated versus non-insulated hydrocoolers, were also made. Calculations to determine the effect of condensation of water on the side-walls were supported by results of small-scale laboratory tests. The laboratory test apparatus was designed to measure the quantity of water that condenses on the sidewalls of a metal tank containing agitated ice water under various typical wet and dry bulb temperature conditions.

Calculations revealed that on a typical hot summer day (95° F. d.b. and 80° F. w.b.), approximately 10 percent of the refrigerating capacity of a hydrocooler is used to overcome the effects of water condensing on the sidewalls of an uninsulated hydrocooler. Often as much as a 50 percent increase in hydrocooler efficiency is possible by avoiding unnecessary heat loads, extraneous sources of heat, and by maintaining full product load during operation.

#### H. Cooling Citrus Fruit

This research is designed to develop improved methods, operating practices and techniques for use in existing and new facilities for more efficient cooling of citrus fruit.

At Orlando, Fla., and Athens, Ga., research on thermal properties and heat transfer characteristics was continued. A manuscript for a technical bulletin entitled "Thermal Properties and Heat Transfer Characteristics of Marsh Grapefruit was completed. A significant interaction was found between rind thickness, moisture content of the rind and juice vesicle, thermal conductivity of the rind and juice vesicles, and specific gravity. Also, as the harvest season advances from October through May, fruit was found to become more dense, its rind becomes thinner and the moisture content of the rind decreases. These findings are consistent with the observed increase in effective thermal diffusivity in relation to length of harvest season. A Marsh grapefruit, 4 inches in diameter, having an initial temperature of 85° F., is at a mass-average temperature of 50° F. after 45 minutes of cooling in a well-agitated water bath at 35° F.

At Gainesville, Fla., the report on a study of the performance of an experimental forced-air precooler at the University of Florida Campus Packinghouse with Florida citrus was further revised and edited for publication as a marketing research report. The manuscript now has the title "Experimental Forced-Air Precooling of Florida Citrus." The basic findings included in this report were previously reported.

Data obtained with the portable forced-air precooling unit on citrus fruit by the Lake Alfred Citrus Experiment Station were summarized and analyzed. Computers were used by personnel of the Gainesville, Fla., and Athens, Ga., field offices and personnel of the Fresh Fruit Handling Section, Florida Citrus Experiment Station for performing analysis of variance and Duncan's multiple range test on the precooling data (temperature reduction value). A draft of a manuscript, "Forced Air Precooling of Citrus Fruits on a Moving Conveyor," was prepared by personnel of the Florida Citrus Experiment Station.

In obtaining the data, 310 test runs were made: 186 on oranges, 68 on "Temples" and 56 with grapefruit. The trailer-mounted forced-air precooling unit ran for a total of 384 hours using 16,133 kilowatt hours of electricity. It is estimated that 115,300 individual fruit were cooled in the test operation with the machine.

This research shows: (a) Citrus fruit can be cooled with air as low as 0° F. without freeze damage, providing the fruit is not exposed too long. A sharp temperature gradient across the five cooling units from 21° down to 0° F. was more efficient than a shallower gradient from 25° down to 8° F.; (b) under optimum conditions, median size (200) oranges could be cooled 2° per minute for the first 15 minutes, thereafter the cooling curve tended to flatten; (c) in the most successful bulk runs with Valencia oranges cooling rate was 0.8° to 0.9° F. per minute and net power consumption was about 1.0 watt-hour per pound of fruit cooled 1° F.; (d) regression equations for temperature drop in

degrees Fahrenheit vs. fruit size which were developed from test runs with 200 size oranges in bulk give temperature drops of  $1.40^{\circ}$  F. and  $0.74^{\circ}$  F. when cooling times of 20 minutes and 33 minutes, respectively, were used; (e) "Temples" tended to cool faster than oranges or grapefruit. There was little difference in the cooling rate for oranges and grapefruit of identical size; (f) of the containers tested, Vexar (polyethylene mesh) bags cooled very well, open top wirebound boxes cooled well, consumer shrink-film packs cooled moderately well, ventilated poly bags were difficult to cool. Open telescope cartons became too distorted to lid properly after cooling; and (g) cooling of closed ventilated cartons or closed wirebound boxes was unsatisfactory.

Electric power cost information and design guidelines for precooling citrus in continuous flow with forced air also will be made available for industry use in a Department publication. This research indicates that there is a potential for improved quality maintenance of precooled citrus, with competitive cost, through application of air instead of water as the cooling medium.

#### I. Cooling Vegetables

This research at Athens, Ga., and Gainesville, Fla., is designed to develop improved methods, operating practices, and techniques for use in existing and new facilities for more efficient cooling of vegetables.

Because of a move of the Athens, Ga., field office to a new location on the University of Georgia campus and consequently, a change in laboratory facilities, it was necessary to design and construct a new laboratory test apparatus for conducting studies on heat transfer characteristics of single specimens of vegetables to air at varying temperatures and rate of flow. Although the test facility was completed, sufficient time was not available to conduct tests with sweet corn as planned.

At Gainesville, Fla., research on heat transfer characteristics of vegetables during forced-air precooling was initiated late in the report period.

Preliminary precooling tests were made at the Campus Packinghouse on small lots of snap beans and tomatoes to become more familiar with the operation of the unit and to aid in the determination of the best method of thermocouple placement for temperature measurement. A smaller chamber, 18 inches square, was built for use in the vegetable precooling tests. Further preliminary tests were made by cooling snap beans in this chamber with a load depth of 18 inches. The beans cooled from  $75^{\circ}$  F. to  $35^{\circ}$  F. in 15 minutes, with an entering air temperature of about  $25^{\circ}$  F. and an airflow rate of about 350 feet per minute. The difference in temperature between the surface and center of the beans was less than  $2^{\circ}$  F. for the entire test run.

#### J. Handling Vegetables in Pallet Boxes

1. Tomatoes. Recent developments in the production and harvesting of tomatoes, such as mechanical harvesting for processing, has brought about an

urgent need for the development of larger containers than field boxes for handling this commodity. Because of this need, research on handling and ripening tomatoes in pallet boxes was undertaken at East Lansing, Mich., under a cooperative agreement with the Michigan Agricultural Experiment Station.

Research on this project during the report period was confined to revising and editing the manuscript, "Handling Tomatoes in Pallet Boxes," based on the final report submitted under the above agreement. The manuscript is awaiting Department clearance for submission to the Government Printing Office.

2. Sweetpotatoes. This research is designed to increase the efficiency and reduce the unit cost of handling, curing, storing, and preparation for market of sweetpotatoes and to minimize losses from spoilage and deterioration. This work is being conducted at Raleigh, N. C., under a cooperative agreement with the North Carolina Agricultural Experiment Station and the North Carolina State Department of Agriculture.

During the report period, research on this area was confined to the completion of a manuscript, "Optimum Lowest Cost Sweetpotato Harvesting and Handling Systems," which contains the details of the research covered under the above agreement.

#### K. Handling and Preparing Pecans for Market

This research at Athens, Ga., is directed toward developing more efficient work methods and operating procedures, equipment, and devices for the handling and preparation for market of pecans in producing areas of the Southeastern United States.

During the report period conditioning and cracking tests were conducted with pecans for the purpose of obtaining preliminary information on the effects of variety, nut size, and conditioning on the force required to crack and the yield of perfect halves during shelling. Random samples of approximately 50 nuts were obtained for each of 8 size groups (8/16-15/16) of seedling pecans and 4 size groups (13/16-16/16) of Stuarts. Half of the nuts (25) in each sample were conditioned by soaking them in clear water for 2 hours and the other half were used as a control. All nuts were cracked with an experimental cracker and the force required to crack was recorded. The nuts were shelled by hand and the number of perfect halves counted.

It was found that the mean cracking force for the 8 size groups of seedling pecans ranged from 231-336 pounds for the untreated nuts and from 185-284 pounds for the nuts that were conditioned before cracking. The yield of perfect halves ranged from 62-84 percent for the untreated nuts and from 66-95 percent for the conditioned ones. The mean cracking force for the 4 size groups of Stuarts ranged from 205-342 pounds for the untreated nuts and from 197-261 pounds for those conditioned. The yield of perfect halves ranged from 75-96 percent and from 96-100 percent respectively, for the untreated and conditioned nuts.

These tests indicate a considerable amount of variation in the force required to crack, both among varieties and among size groups within varieties. They also indicate that conditioning reduces the force required to crack and increases the yield of perfect halves in shelling.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Handling, Degreening, and Packing Citrus Fruit

Gaffney, Jerome J. 1967. Electronic Color Sorting of Florida Citrus Fruit and Vine-Ripened Tomatoes. Paper presented at Florida Section ASAE Meeting, Winter Park, Florida. May 6, 1967.

Bowman, Earl K. 1966. Citrus Packing Methods Improvement. Paper, Florida State Horticultural Society, Miami Beach, Florida, October 24-27, 1966. Proceedings Vol. 79, 1966.

Bowman, Earl K. 1966. Laboratory Study of Pallet Box Volume-Capacity Relative to the Standard Field Box. Paper presented at Packinghouse Day, Citrus Experiment Station, Lake Alfred, Florida. September 7, 1966.

Gaffney, Jerome J. 1966. Research on Automatic Color Sorting of Florida Citrus Prior to Degreening. Paper presented at Packinghouse Day, Citrus Experiment Station, Lake Alfred, Florida. September 7, 1966.

Gaffney, Jerome J. 1967. Potential Applications for Machine Color Sorting of Citrus in Florida Packinghouses. Paper presented at Fresh Citrus Shippers' Association Meeting, Orlando, Florida. February 1, 1967.

Handling and Packing Deciduous Fruit

Stout, B. A., Dewey, D. H., Vis, E. G., and Herrick, J. F., Jr. 1966. A Prototype Hydrohandling System for Sorting and Sizing Apples Before Storage. ARS 52-14, August 1966, 12 pp.

Stout, B. A., Dewey, D. H., and Herrick, J. F., Jr. 1966. A Prototype Hydrohandling System for Prestorage Sorting and Sizing Apples. Paper before 17th International Horticultural Congress, University of Maryland, College Park, Maryland, August 15-20, 1966.

Dewey, D. H. 1966. Field Trials of A Hydrosystem for Sizing and Sorting Apples for Storage in Bulk Boxes. Paper before 72nd Convention of the International Apple Association, Las Vegas, Nevada, November 1, 1966.

Burt, Stanley W. and Patchen, Glenn O. 1966. Grading and Sizing Apples With Brushes. ARS 52-18, December 1966, 14 pp.

1966. Sizer Gives Bruises the Brush. Western Fruit Grower, April 1966.

1966. Underwater Apple Handling to be Tested. Produce Marketing, September 1966.

Herrick, Joseph F., Jr. 1967. Hydrohandling Apples. Paper before 108th Annual Meeting State Horticultural Association of Pennsylvania, York, Pa., February 7, 1967.

1967. Brush-Sizer for Apples. Agricultural Research, April 1967.

Forbus, W. R., Jr. 1967. Layout Guidelines for Peach Packinghouses. ARS 52-19, March 1967, 32 pp.

Herrick, Joseph F., Jr. 1966. The Use of Pallet Bins in Harvesting, Storing, and Distributing Fruits and Vegetables in the East and Midwest. Paper before the Fourth Annual Eastern Pallet Users' Conference, Syracuse, New York, November 1, 1966.

#### Handling and Packing Potatoes

Bowman, Earl K., Yost, Gilbert E., and Greene, R. E. L. 1966. Bulk Handling Spring Crop Potatoes from Harvester to Packing Line. Marketing Research Report No. 761, November 1966, 35 pp.

Hunter, James H. 1967. Studies in the Accuracy of A Rubber Spool Type Potato Sizer. Maine Farm Research, April 1967, pp. 37-41.

Potter, Kenneth E. 1966. The Shape Characteristics of Maine Grown Long White Potatoes and Their Effect on Commercial Grading Practices. Maine Farm Journal, Vol. 14, No. 2, July 1966, pp. 40-44.

#### Handling and Packing Vegetables

Fisher, Ed. 1967. Automatic Weight-Sizer for Celery Cheaper, More Accurate than Hand Labor. Sunshine State Agricultural Research Report, Vol. 12, No. 1, January 1967, pp. 4-5.

#### Storage of Potatoes

Schaper, L. A., Yaeger, E. C., Flikke, A. M., and Junnilla, W. A. 1966. Storage Temperature Maintenance and Its Effect on Processed Potatoes. Paper before Potato Association of America, Ft. Collins, Colorado, July 25-29, 1966. Also published in American Potato Journal, May 1967, Vol. 44, No. 5, pp. 159-164.

1966. Potato Storage--60,000 Cwt. Door-Per-Bin. Miscellaneous Publication No. 1024, July 1966.

1966. New Fronts for Bins. Agricultural Research, Vol. 15, No. 4, October 1966, p. 15.

1966. Frost-Free Storage. Agricultural Research, Vol. 15, No. 4, October 1966, p. 14

Schaper, L. A. 1967. Potato Research Center in Wide Range of Work. Grand Forks Herald, April 8, 1967.

1967. Potato Storage--20,000 Cwt. Arched Roof. Miscellaneous Publication No. 1057, June 1967.

#### Cooling Vegetables

Grizzell, William G. and Bennett, A. H. 1966. Hydrocooling Stacked Crates of Celery and Sweet Corn. ARS 52-12, July 1966, 40 pp.

#### Handling Vegetables in Pallet Boxes

Fluck, Richard C. and Splinter, William E. 1966. Infrared Gas Analysis for Measuring Mechanical Damage to Biological Tissue. Paper before 1966 Winter Meeting, American Society of Agricultural Engineers, Chicago, Ill., December 6-9, 1966.

#### General

Grizzell, W. G. and Beeman, James 1966. Predetermined Elemental Time vs. Time Study Methods to Determine Labor Requirements for Agricultural Operations. Paper before American Society of Agricultural Engineers, Chicago, Ill., December 7-10, 1966.

## AREA NO. 5. LIVESTOCK, MEAT, AND WOOL - MARKETING FACILITIES, EQUIPMENT AND METHODS

Problem. Many of the livestock, meat, and wool marketing, slaughter, and warehouse facilities occupied today are obsolete and the work methods that can be used in such facilities are antiquated. As a consequence, labor costs are excessive and they are increasing. Many firms still are occupying facilities designed primarily for handling rail receipts and rail shipments even though the majority of these products today are moved by motortruck. This situation also adds to handling costs. Numerous firms are occupying "makeshift" facilities which were designed for other uses or for work methods and operations of a bygone era when labor costs were low. Changes in transportation systems, population growths and shifts, and advancements in technology also have brought about changes in the types of facilities-- such as livestock auction markets, commercial feedlots, hotel supply houses, and specialty meat processing plants. Most private firms handling livestock, meat, and wool lack the technological and engineering skills necessary to plan and develop suitable facility layouts and designs and to select the types of equipment needed. Therefore, engineering and related research is needed to provide guidelines for industry to increase efficiency; including the designing of improved plant layouts, which will provide proper arrangement of work areas to minimize travel distances and excessive handling and the development of work methods that will permit use of mechanized and automated equipment rather than the relatively high-cost manual methods now used in many plants.

### USDA PROGRAM

The Department has a continuing long-term marketing research program involving agricultural and industrial engineers, agricultural economists, and meat scientists engaged in both basic and applied research to develop new and improved methods, equipment, processes, and facilities for livestock markets, meatpackers and wholesalers, and wool warehousemen. Livestock market research is carried on at Columbia, Mo., in cooperation with the Missouri Agricultural Experiment Station. Part of this work also is in cooperation with the Central Missouri Livestock Auction, Mexico, Mo. One livestock market research project is conducted under a research cooperative agreement with the Computer Research Center, University of Missouri, Columbia, Mo. Research on livestock slaughtering and on meatpacking and wholesaling is headquartered at Stillwater, Okla., and is cooperative with the Oklahoma Agricultural Experiment Station. One segment of the meat research is conducted under a research cooperative agreement with the Nebraska Agricultural Experiment Station, Lincoln, Neb. Wool warehouse research will be conducted at the Columbia, Mo., field location.

The Federal effort devoted to research in this area totals 5.1 scientific man-years; 2.0 man-years (1.2 man-years intramural and 0.8 man-year extramural) on livestock; 2.4 man-years (2.0 man-years intramural and 0.4 man-year extramural) on meat; and 0.7 man-year on program leadership. No research is currently being done on wool warehouses.

#### REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

##### A. Automation of Sales Operations on Livestock Markets

Electrically operated gates, developed under a research cooperative agreement with the Missouri Agricultural Experiment Station, continue to operate very satisfactorily. Prototype gates have been in continuous use at the entrance and exit of the sales ring on the Central Missouri Livestock Auction, Mexico, Mo., for about 18 months.

Plans for the electric gate have been provided to a terminal stockyards company which installed gates in the sales ring of its new feeder cattle auction facility. These gates have now been operating successfully about 6 months. Several other market operators have indicated they are considering installing electrically operated gates on their sales ring.

A descriptive report entitled "Electrically Operated Gates for Livestock Markets" was completed and published in April 1967. A second and final report providing construction details, drawings, and additional information on the prototype gates is in draft form and will be published by the Missouri Station during the Fiscal Year 1968.

##### B. Automating the Processing of Sales Data on Livestock Markets

A computer system for processing sales and accounting data on livestock auction markets has been developed under a research cooperative agreement with the Computer Research Center, University of Missouri, Columbia, Mo. The types of information needed for efficient handling of sales data were determined from analyses of current handling procedures and office records. Core space (information storage) requirements were based on the volume of information to be processed on a peak volume day.

Components of the system were selected from commercially available equipment capable of processing the types of information needed, providing adequate core space, and having sufficient operating speed to keep abreast of the fastest selling operation. Due consideration was also given to simplicity and economy in selecting components.

The system uses an IBM 1130 computer, an IBM 514 reproducing punch for use with mark sense cards, sorting and print-out machines. The computer has been programmed and laboratory tested and the complete experimental system installed on the Central Missouri Auction Market, Mexico, Mo. In market testing, the auction clerk uses a lead pencil to mark the coded information for a sales transaction on a preprinted mark sense card, the card is transmitted to the market office through a pneumatic tube, the IBM 514 automatically translates the coded pencil marks into punches on the card, and the card is fed into the computer. The computer calculates total price of the transaction; deducts commission charges, insurance, feed, transportation, and other applicable fees; and makes appropriate entries on the buyer's invoice. The mark sense card provides a permanent record of the transaction.

The computer system minimizes the possibility of errors in computations and preparation of records and accounts, speeds up payment for animals following their sale, provides accurate permanent records of all business transacted and could easily be programmed to handle routine accounting tasks such as payrolls. By leasing computer time to or from other firms in their respective localities, the system can be used economically on most of the 1,725 auction markets in the U.S.

The tests under actual market conditions will be completed and a manuscript covering the result will be prepared during the Fiscal Year 1968.

#### C. Layouts and Operating Criteria for Livestock Auction Markets

At Columbia, Mo., research to update and broaden work previously done by the Branch on improving layouts, work methods, equipment and facilities to increase operating efficiency was initiated in November 1966. Field data were collected on market layouts, flow patterns, handling methods, weighing and selling practices, volumes handled, and labor requirements on selected livestock auction markets in the Midwest, Southeast, and Appalachian areas of the United States. Work has not progressed to the point where research results can be reported.

#### D. Layouts and Work Methods for Hog Slaughtering Plants

At Stillwater, Okla., in cooperation with the Oklahoma Agricultural Experiment Station, a manuscript entitled "Hog Slaughtering and Dressing Systems" was completed and published in September 1966. Results of this research were covered in previous reports.

#### E. Layouts and Work Methods for Hotel and Restaurant Meat Supply Houses

At Stillwater, Okla., a manuscript entitled "Hotel and Restaurant Meat Purveyors--Custom Service Houses--Improved Methods and Facilities" was completed and published in July 1966.

At Hyattsville, Md., an article entitled "USDA Tests Show Promising Ways to Cut Custom Meat Order Costs" was published in the August 1966 issue of Agricultural Marketing.

At Stillwater, Okla., a manuscript entitled "Hotel and Restaurant Meat Purveyors--Frozen Portion Control Houses--Improved Methods and Facilities" was returned to the author in April 1967 so that data on recently introduced meat fabrication equipment could be included in the manuscript.

The significant results of the research covered by these manuscripts were covered in earlier reports.

#### F. Layouts and Work Methods for Small Inedible Rendering Plants

At Stillwater, Okla., field studies were conducted in several rendering plants ranging in size from a one-cooker batch system to a six-cooker operation, plus one continuous rendering system. Based on analyses of these data, discussions with plant owners and managers, and requests for assistance from public agencies and industry groups, it appears that limiting this research to increasing operating efficiency in small inedible rendering plants would not provide the rendering industry adequate guidelines and assistance for management decisions. As the primary interest among renderers today concerns Salmonella control and in response to a request from ARS' Animal Health Division for cooperation on the Salmonella problem, this project has been reoriented to include work on developing suggested layouts, equipment modifications, and operating procedures which will affect Salmonella control and thus be more beneficial to the industry. At the end of the fiscal year this research was being reorganized to include both operating efficiency and Salmonella control.

#### G. Handling and Processing "Hot" Pork Carcasses

During the report year, a research cooperative agreement was negotiated with the Nebraska Agricultural Experiment Station, Lincoln, Neb., to design and test a pilot line, including a continuous flow chill cabinet, for handling and processing "hot" pork products. Plans were developed to move this research from a laboratory feasibility study to the development of prototype equipment and the design of a pilot line operation for use in a commercial packing plant. Based on data developed in the feasibility study, working drawings and specifications have been prepared for the construction of a prototype continuous flow chill cabinet. An agreement has been drafted which provides for tests under actual operating conditions in a commercial packing plant; and at the end of the report year negotiations were underway with a prospective cooperating packer. During fiscal year 1968 it is anticipated that prototype equipment will be constructed and laboratory tested in preparation for actual operating tests in a commercial plant.

#### H. Layouts and Work Methods for Beef and Veal Boning Lines

At Stillwater, Okla., field work was continued on research to develop more efficient work methods, equipment, and layouts for beef and veal boning lines. Data from case studies completed to date have been compiled and tentative results show that a well planned conveyorized line boning about 100 carcasses daily requires three fewer workers and about 20 percent less floor space than a conventional manual line. Comparable savings should be realized for lines handling larger volumes.

A manuscript tentatively entitled "Evaluation of Bone Handling Procedures for Beef Boning Lines" was in rough draft form at the end of the report year. The report provides data on types of equipment and procedures for handling bones at various volumes and transport distances. The conventional boning table and general purpose truck are the most efficient at volumes up to 100 head daily and a transport distance up to 65 feet. For volumes of 100 to 185 head and distances up to about 50 feet, a belt conveyor and truck combination is the most economical. A conveyorized system is recommended for larger volumes and greater distances.

Some preliminary work has been done on reworking bones removed from carcasses to recover the meat left by the boner. The findings to date are that about 20 pounds of usable meat per 100 pounds of carcass bones can be salvaged. These data were developed from bones supplied by only one boning establishment. Additional work will be done on carcass bones obtained from other boning lines. Also, investigations will be made to determine if the meat reclaimed justifies the labor, equipment, and space needed for the operation.

#### I. Methods, Equipment and Facilities for Specialty Meat Plants

At Stillwater, Okla., field studies to collect data for the development of suggested layouts for small, medium and large sausage processing plants were completed. The data obtained served as a basis for developing labor, equipment and maintenance requirements and costs and layouts representing a small plant at 37,500 pounds product output annually, a medium size plant at 75,000 pounds output and a large plant at 187,500 pounds output. From this data, labor and equipment requirements were synthesized for volumes representing a 33 1/3 percent increase and decrease in production from each of the established plant outputs. Thus, data were provided for plants producing at 9 different levels of output.

Agricultural Economists of Oklahoma State University used these data in projecting total plant costs necessary to construct and operate sausage plants representative of these sizes in the Oklahoma area. Portions of these data have been incorporated in an Oklahoma State University report entitled "Economics of Size in Non-Slaughtering Meat Processing Plants."

At the end of the report year, these data were being evaluated to determine what additional information would be needed to prepare a Department publication on increasing efficiency in sausage processing plants.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Automation of Sales Operations on Livestock Markets

Mayes, Herman F., Obermeyer, James H., and McKibben, J. S. 1967. Electrically Operated Gates for Livestock Markets. ARS 52-21, 12 pp.

Layouts and Operating Criteria for Livestock Auction Markets

Webb, Tarvin F. 1967. Improving Operating Efficiency on Livestock Auction Markets. Paper presented at the Annual Meeting of the Virginia Association of Livestock Markets. Charlottesville, Va. January 14, 1967.

Layouts and Work Methods for Hog Slaughtering Plants

Hammons, Donald R. 1966. Hog Slaughtering and Dressing Systems. Marketing Research Report 755. September 1966.

Layouts and Work Methods for Hotel and Restaurant Meat Supply Houses

Brasington, Clayton F. 1966. Hotel and Restaurant Meat Purveyors-- Improved Methods and Facilities for Custom Service Houses. Marketing Research Report 747. July 1966.

Brasington, Clayton F. 1966. USDA Tests Show Promising Ways to Cut Custom Meat Order Costs. Agricultural Marketing, August 1966.

General

Hammons, Donald R. 1967. The Change to On-The-Rail Dressing Systems. Paper presented at the Annual Meeting of the Texas and Southwestern Meat Packers Sausage Institute, Texas A. and M. University, College Station, Texas, April 29, 1967.

#### AREA NO. 6. POULTRY AND EGGS - MARKETING FACILITIES, EQUIPMENT AND METHODS

Problem. Although the production of meat classes of poultry has tended to level off, the rapidly developing demand for further processed poultry meat items, in addition to a strong demand for the traditional whole bird, has resulted in significant changes in methods of product preparation which have increased the demand for equipment and facilities that encourage sanitary and efficient operations. Similarly the production of fine quality eggs from large commercial flocks, that are now the major source of table quality eggs throughout the country, calls for drastic changes in the facilities, equipment and methods for preparing eggs and egg products for market. These changes have had an impact on the poultry processing and egg grading and packing plant operations throughout the country. In adjusting to these changes industry has tried in many cases to work out the problems involved on an individual plant basis. In the main, the changes effected, have furnished only temporary relief in the area of plant expansion needs and are of little help in developing guidelines for new plants or in solving general plant production problems and problems involving new processes. The research that the Department has undertaken in this area has been successful in developing some of the basic guidelines that industry needs and that are now being effectively used by many plant operators. However, in order to continue to improve operating efficiency in existing facilities, and to be in position to provide effective assistance in planning new or expanded facilities needed in connection with many of the recent food processing and marketing trends; develop plant layouts, devices, and equipment, and efficient work methods for the handling, processing, grading, and packing of poultry, eggs and egg products in this changing environment; this research effort needs to be continued and expanded.

#### USDA PROGRAM

The Department has a continuing long-term program involving engineers and marketing research analysts engaged in both basic and applied research to develop more efficient work methods, techniques, operating procedures, devices, and equipment and to design improved facilities for the handling and preparation for market of poultry, eggs, and egg products. Research on chicken-class poultry processing operations is carried on in commercial poultry processing plants in the Southeast by Department personnel at Athens, Ga., in cooperation with the College of Agriculture Experiment Stations, University of Georgia. Research on turkey-class poultry processing, egg products processing, and the cleaning, grading, and packing of shell eggs is carried on in West Coast turkey processing facilities and in egg grading and packing plants, in cooperation with the California Agricultural Experiment Station at Davis. Contract research to design, construct and test a mechanized turkey deboning line to increase

productivity and maximize the yield of prime deboned meat cuts, is being carried out by the Gordon Johnson Company, Kansas City, Mo.

The Federal effort devoted to research and development work in this area during the Fiscal Year 1967 totaled 4.6 scientific man-years of which 2.6 man-years (including 0.5 man-year of contract work and 0.1 man-year under a cooperative agreement with the University of Georgia) is devoted to poultry; 1.0 man-year (including 0.4 man-year under a cooperative agreement with the University of California) to shell eggs and egg products; and 1.0 man-year to program leadership.

#### REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

##### A. Methods, Equipment, and Facilities for Grading and Packing Eggs

This research completed in Hyattsville, Md., last year was reported in MRR-744 "Evaluation of Mechanized Egg-Grading and Packing Equipment." It evaluates and compares the principal mechanized egg grading and packing lines and provides guidelines for egg grading plant operators in determining the degree of mechanization that should be most efficient in their respective operations and in selecting the combinations of mechanized egg grading and packing equipment that will yield the greatest output per worker and equipment dollar at specified production and product quality levels.

##### B. Improved Methods, Techniques and Equipment for Cleaning Eggs

This research, completed at Davis, Calif., last year was reported in MRR-757 "Improved Methods, Techniques, and Equipment for Cleaning Eggs." It provides machine design specifications and time, temperature, and sanitation requirements for operating and maintaining egg cleaning equipment that maximizes the yield of clean eggs while minimizing breakage and hazards from spoilage organisms.

##### C. Improved Layouts and Engineering Designs for Egg Grading and Packing Plants

This long term research carried on at Davis, Calif., is directed toward the development of improved building design and layouts for small egg grading and packing plants involving preparation of engineering design drawings, the development of building specifications, and facility and equipment layouts. The recent trend in the poultry industry indicates a need for small efficient egg grading and packing plants where the production of a few large commercial flocks are handled on one of the farms. This trend has given rise to a need for information on plant facilities including equipment arrangements, storage space requirements, egg cooling facilities, and structural design guidelines. The average operator of a small plant, generally has started operations in a small makeshift facility and then as flock size and production increased, the plant has been enlarged, creating

inefficient operations and hazards to product quality. This situation has created a need for layouts which are designed to meet expansion needs.

During the earlier phases of this research a number of commercial plants within the desired size range were studied to evaluate the problem areas and to provide a basis for designing improvements. Building specifications, layouts, and functional area space requirements were determined to furnish guidelines for setting up design criteria.

During the report year a layout and design manual was prepared in draft form. Materials handling, materials storage, processing areas and product storage were considered individually and jointly in terms of overall arrangement, inter-relationship, expansion potential, and structural design requirements. Procedures for calculating initial and changing space requirements, and techniques for planning functional work and storage areas were developed for a wide range of operating conditions. Structural design specifications and engineering drawings have been prepared for the typical plant in this volume range.

D. Development of Equipment and Methods For Pasteurizing Liquid Whole Eggs In Small Volume Egg Breaking Rooms

This research, which is carried out under a research cooperative agreement by the University of California's Department of Food Science and Technology, is part of a long range program at Davis, Calif. It is designed to develop pasteurizing equipment that will meet the needs of small egg grading and packing plants that have found it advantageous to break out and freeze undergrade eggs, instead of marketing them in the shell at a considerable loss. With recent requirements calling for the pasteurization of liquid eggs by both State and Federal authorities, an urgent need has arisen for equipment that can handle the production of these small volume operators as effectively as pasteurizing equipment presently employed in large volume plants.

Under this project studies have been made of egg pasteurization by the batch method (because of its adaptability to handling small quantities of liquid) to establish a balance between time and temperature parameters that will provide the necessary microbial kill without damage to the functional properties of the egg liquid and to determine the feasibility of designing equipment for operation under varying conditions of product volume and temperature.

During the report year three small commercial vats were used to test the time and temperature requirements for both heating and cooling commercial quantities of liquid egg under various operating conditions explored earlier with small scale laboratory vessels. Tests were conducted under static conditions to determine their effect on the functional properties of the egg and lethality on *Salmonella*. The results showed that, although no significant changes were noted in the functional properties of the liquid

whole egg, space heating (between liquid surface and cover of the vessel) was necessary to eliminate recontamination from the foam caused in vat agitation. When space heating was used and the liquid egg was held at 135° F. for 9 minutes a  $10^6$  Salmonella kill was effected. The bacteria levels of Salmonellae in unpasteurized liquid whole egg from twenty-five (25) California egg breaking rooms were determined. Theoretical calculations of the thermal death time and temperature for these bacteria were made and then verified by the results of studies of the thermal death time and temperatures recorded for actual operations. From these data, specifications for a prototype batch pasteurization unit for laboratory and commercial testing have been developed.

Three reports covering the results have been completed; one was presented at the annual meeting of the Poultry Science Association and two are being submitted for publication in the technical journal "Poultry Science."

#### E. Improved Methods and Equipment For Cutting-Up and Packing Chickens

This research conducted at Athens, Ga., involves a study of methods, equipment and facilities for dismembering, cutting up and packing broiler class chickens.

Time and motion studies of cut-up methods used in small volume operations (in plants where the cut-up pack mainly represents the trimmed bird fraction of a ready-to-cook whole bird ice-packed operations) were completed and development of an efficient small cut-up line layout was started.

The study of cut-up operations was expanded to include large volume operations in Georgia and North Carolina.

Developmental work on mechanizing the cut-up operation was initiated. A machine for splitting the breast while removing the backbone was designed, constructed and tested both in the laboratory and in commercial plants. Only minor design changes appear to be needed before full-scale field trials are undertaken. It is estimated that the machine can reduce the labor costs of the breast cutting operation by 50 percent while reducing worker injury hazards and improving cutting accuracy and consistency. Disclosures required in preparing an application for a public patent are being undertaken.

#### F. Improved Layouts and Designs for Poultry Processing Plants

No progress to report on this research conducted at Athens, Ga.

#### G. Improved Methods, Equipment and Facilities for Improving Chicken Processing Plant Efficiency Through Balanced Inspection and Evisceration Operations

This research, which was carried out under a contract with the American

Scientific Corporation, Alexandria, Va., in selected plants on the Delmarva Peninsula, was completed last year. During this report year a report on the results of the study, "Poultry Eviscerating and Inspection Efficiency" was prepared by Department personnel and has been submitted for publication. It will provide plant operators and the Department's Inspection Service with guidelines for the most efficient inspector-work crew mix at specified production levels and processing equipment combinations.

H. Improved Methods and Equipment for Handling Live Chickens by Commercial Processing Plants

This research, headquartered at Athens, Ga., involves studies of live chicken handling operations to determine the causes of the relatively high rate of bruising of live chickens prior to slaughter and to develop improvements that will reduce this costly damage to product quality with minimum additional cost.

During the report year evaluation of live chicken handling operations to determine labor requirements and locate areas or operations where downgrade bruising occurs were continued in typical commercial facilities in Georgia, North Carolina, and Virginia. The research included: (1) A study of the equipment and facilities employed in approximately 40 live handling operations and detailed analysis of the work methods used; (2) motion picture records of three experimental mechanical loading systems to document advances made in mechanization of the operation and as a guide for improvements that might be developed; (3) studies to determine the source of downgrading damage to chickens during specific live handling, transport and grow out operations; and (4) the second of a more extensive series of tests (100 birds from 30 different Georgia flocks) to confirm the amount of bruise damage prevailing in the commercial flocks prior to the arrival of live handling crews. In an attempt to make the data from the Georgia tests more meaningful and to correlate the housing conditions to a specific situation, similar data were collected from 50 Virginia grower houses of various sizes and layouts and using different types of equipment.

Results show that chickens are not likely to be bruised enroute from the farm to the processing plant but that more than 50 percent of the bruised live birds had been bruised prior to the arrival of the catching crews.

Studies of the use of limited external stimuli (light and sound) indicate that blue-white lighting during the grow-out period (white lights turned off and blue lights turned on when caretaker enters flock quarters) has a quieting effect on chickens that results in fewer bruises at the time of catching. Arrangements have been made to confirm these results by large scale tests.

Experimental mechanized coop loading equipment to reduce bruise damage to chickens during live handling and to reduce labor requirements and drudgery of catching and loading chickens was designed, constructed and tested in the

laboratory. The equipment consists of a conveyor system to transport chickens onto the truck and dispense them into the coops with a minimum of handling by the crews. The test results are encouraging but further design modifications are necessary before commercial scale tests can be undertaken.

I. Improved Methods, Equipment and Facilities for Chilling, Weighing, and Packing Turkeys

The field studies for this research, conducted at Davis, Calif., covering the development of improved methods and equipment for weighing and packing turkeys were completed last year. A report "Improved Equipment for Weighing and Packing Turkeys" setting forth the results has been prepared, cleared and submitted for publication. It presents the design detail for a semi-mechanized turkey packing line that reduces labor requirements required for preparing the turkey for weighing, placing it in a plastic bag, marking the exact weight on the bags and sealing it. These studies show a possible labor saving of 15 percent as compared with conventional equipment and methods.

J. Improved Methods, Equipment and Facilities for Preparing Turkey Specialty Items

This research, carried out on an in-house basis at Davis, Calif., and under contract with the Gordon Johnson Co., Kansas City, Mo., is directed toward an engineering analysis of the current methods, equipment and facilities for dismembering and deboning turkeys and the development of improved equipment, facilities and work methods for decreasing labor inputs and yield of prime meat cuts while keeping hazards to product quality at a minimum. Evaluation of current methods, equipment and facilities is being carried out by Department personnel; and the designing, construction and testing of a mechanized deboning line is being carried out under contract.

During the report year, observations made of typical turkey deboning operations and evaluation of selected phases provided Department researchers with an understanding of the critical problems in mechanizing the process as it is currently carried on in commercial plants.

Department researchers worked with the contractor in selecting a processing plant in which a typical deboning operation could be evaluated (for comparison with performance of the experimental line later) and where management would also cooperate by permitting installation and testing of an experimental line.

The contractor's initial report containing a description of and design and structural specifications for a proposed mechanized line was unacceptable because it lacked engineering data to support a number of critical design features. Development of the necessary supporting data was started.

The design of a powered cutting tool for the efficient removal of meat from the turkey carcass was made by Department researchers. Components for its construction are presently being procured. After construction and testing it is planned to use the tool on a conventional line and on the experimental line.

#### PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

##### Methods, Equipment, and Facilities for Grading and Packing Eggs

Forbus, Jr., W. R., and Hamann, J. A. Evaluation of Mechanized Egg-Grading and Packing Equipment. Marketing Research Report No. 744, July 1966.

Hamann, J. A. 1966. Egg Plant Equipment and Layout. A technical paper presented at the Neppco Egg Quality School, Blacksburg, Va., July 1966.

##### Improved Methods, Techniques and Equipment for Cleaning Eggs

Hamann, J. A. 1966. An Improved Egg Cleaner. A technical paper presented at the 13th World's Poultry Congress, Kiev, U.S.S.R., August 1966.

Walters, R. E.; Robbins, R. O., Brant, A. W., and Hamann, J. A. 1966. Improved Methods, Techniques, and Equipment for Cleaning Eggs. Marketing Research Report No. 757, October 1966.

##### Improved Layouts and Engineering Designs for Egg Grading and Packing Plants

Walters, R. E., and Rodda, E. D. 1967. Egg Processing Plant Design and Layouts. A technical paper presented at the 60th Annual meeting of the American Society of Agricultural Engineers, Saskatoon, Saskatchewan, Canada, June 1967.

##### Development of Equipment and Methods for Pasteurizing Liquid Whole Eggs in Small-Volume Egg Breaking Rooms

Patterson, G. W. 1966. Further Developments in Batch Pasteurization of Liquid Whole Egg. A technical paper presented at the 55th Annual meet of the Poultry Science Association, Logan, Utah, August 1966.

##### Improved Methods and Equipment for Cutting-Up and Packing Chickens

Hamann, J. A. 1966. Poultry Meat Specialities in the United States. A technical paper presented at the University of Stuttgart, Stuttgart, Germany, August 1966.

Improved Methods and Equipment for Handling Live Chickens by Commercial Processing Plants

Childs, R. E., White, H. D. 1966. Influence of Grower House Facilities on Handling Live Chickens. A technical paper presented at the winter meeting of the American Society of Agricultural Engineers, Chicago, Ill., December 1966.

Childs, R. E. 1967. An Analysis of Live Chicken Handling Operations. A technical paper presented at the annual meeting of the Southeastern Poultry and Egg Association Convention, Atlanta, Ga. January 1967.

Childs, R. E. 1967. Live Handling of Broilers to Decrease Losses. A technical paper presented at the Eighth Annual Poultry Health and Management School, Nashville, Tenn., May 1967.

Childs, R. E. 1967. The Latest Methods and Problems of Handling Live Broilers. A technical paper presented at the annual meeting of the Alabama Poultry Industry Association, Pell City, Alabama. June 1967.

Improved Methods, Equipment and Facilities for Preparing Turkey Specialty Items

Hamann, J. A. 1967. Problems and Progress in the Development of a Mechanized Deboning Line. A technical paper presented at the Poultry Further Processing Conference, Columbus, Ohio, June 1967.

#### AREA NO. 7. CONSUMER PACKAGES AND SHIPPING CONTAINERS

Problem. It costs about 8 billion dollars a year to package food products, but without shipping containers and various other types of packages it would be impossible to move farm products efficiently from the widely dispersed areas of production through our complex marketing system to millions of consumers. New or improved packages and containers must be developed and evaluated to do this job more effectively. Continuing changes characterized the American marketing system. In protecting, distributing and selling perishable agricultural commodities, packages, and containers must respond to a number of marketing system changes, such as changes in (1) consumer preferences, (2) merchandising practices, (3) transportation equipment and techniques, (4) handling methods and equipment, (5) market services, (6) market organization, and (7) market outlets.

Packages and containers not only respond to changes, but changes in them stimulate improvements in other parts of the marketing system. The job of the research program in this area is to see that packages and containers keep pace with changes in the marketing system and reduce the cost of handling, transporting and storing agricultural commodities. It also seeks to improve service to consumers, promote greater sales of farm products, and increase the income of producers.

#### USDA PROGRAM

This is a continuing program of applied research conducted by marketing specialists, industrial engineers, and agricultural economists to (1) develop new or improved consumer packages, and shipping containers for domestic and export marketing of agricultural products; (2) evaluate them from the standpoint of cost of materials and direct labor to pack, and their ability to reduce product damage and increase product salability; (3) determine at which point in the marketing system packaging can be done most effectively; (4) improve the efficiency of packaging methods to cut costs; and (5) investigate the needs for and benefits of container standardization and simplification. Current packaging and container research is on deciduous fruits, citrus fruits, vegetables, cut flowers, poultry and dairy products. The program is carried on in cooperation with experiment stations and industry in California, Oregon, Washington, Georgia, North Carolina, Virginia, Ohio, Michigan, Iowa, New York, New Jersey, Pennsylvania, Alabama, and Florida; at field stations in Orlando, Florida; Fresno, California; and Yakima, Washington; in other main producing areas; and in the principal terminal markets. This program involves 10.5 scientific man-years: (a) Horticultural products, 7.5; (b) animal products, 0.7; (c) overseas

markets, 2.3.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Packages and shipping containers for horticultural products

1. Apples. A manuscript reporting on research conducted in 1965 and 1966 on evaluation of shipping containers for cell and tray-pack Golden Delicious apples is being prepared. Chipboard cell partitions, deep-pocket molded pulp trays and molded polystyrene foam trays were evaluated. The deep-pocket molded pulp and molded polystyrene foam trays performed as well but cost less than the conventionally used corrugated cell partition boxes. The chipboard cell partition boxes and conventional pulp trays did not protect the apples as well as the corrugated partition cell boxes. The results of work on the development of consumer packages for McIntosh apples were published in ARS 52-16, October 1966.
2. Apricots. Apricots jumble-packed in full telescope fiberboard boxes bruised less than those shipped in face-packed wood boxes. This finding was based on transcontinental test shipments made during the 1966 apricot season. The cost of containers, equipment, labor and transport to pack and ship apricots in jumble-filled fiberboard and place-packed wood boxes will be determined during the 1967 apricot season.
3. Italian Prunes. Italian prunes shipped in jumble-packed wirebound fiberboard - wood veneer boxes bruised less than those shipped in face-packed wood veneer baskets. Transcontinental test shipments of Italian prunes packed in these two containers were made during the 1966 season. The cost of containers, equipment, labor and transport to pack and ship Italian prunes in jumble-pack and face-pack containers will be determined during the 1967 season.
4. Grapes. California grapes packed in expanded polystyrene foam shipping containers arrived in Eastern markets with slightly fewer bruised and shattered berries than grapes packed in standard wood display lugs. These results were obtained from test shipments made during the 1966 grape season. Additional test shipments are being made during the 1967 grape season. The costs of packing, handling and transport for grapes packed and shipped in the polystyrene foam and standard wood boxes will be obtained during the 1967 season. Receivers generally liked the polystyrene foam boxes for grapes, although breakage of the boxes was a problem in test shipments made during the 1966 season. The boxes were redesigned for the 1967 tests.

5. Temple Oranges. Temple oranges packed and shipped in polyvinyl chloride (PVC) cell trays arrived in terminal markets with less bruising than comparable oranges place-packed in wirebound wood crates or fiberboard boxes. Sixteen truck test shipments of Temple oranges packed in PVC shipping trays in fiberboard boxes and place-packed in fiberboard boxes and wirebound crates were made from Florida to five Eastern terminal markets. The cost of packing Temple oranges in the PVC cell trays was \$.59 per 4/5 bushel box equivalent, \$.42 for wirebound crates and \$.31 for fiberboard boxes. A manuscript is being prepared for publication.

6. Grapefruit and Murcott Oranges. Results of exploratory studies on packaging grapefruit halves and peeled whole Murcott oranges at shipping point were promising. Further studies are planned during the 1967-1968 citrus season to test the feasibility of marketing packaged grapefruit halves and peeled oranges in vending machines, restaurants, and retail food stores.

7. Plums, Nectarines, and Bartlett Pears. Investigations to determine the costs and feasibility of marketing Western plums, nectarines, and Bartlett pears packed in three sizes of shipping containers and prepackaging them in terminal prepackaging plants and in retail stores are being made under contract by Food Industries Research and Engineering. The fruit is being packed in place-packed boxes, jumble-packed boxes and in large bulk-bin boxes. One pilot test shipment from California to Boston, Massachusetts, was completed in 1966. Four test shipments of each of the three kinds of fruit will be made in 1967.

8. Pears. The results of the work done on the development of prepackaging pears at shipping point were published in Marketing Research Report No. 758, November 1966.

9. Tomatoes. Results of the work done on the cost and use of ozone in tomato ripening rooms were published in ARS 52-17, October 1966.

10. Tomato Transplants. In cooperation with Crops Research Division, ARS, the feasibility of developing improved containers for shipping tomato transplants from Georgia to northern tomato producing areas was investigated. Tomato transplants are usually harvested and then graded and packed in bunches wrapped with Kraft paper in packing sheds. The paper wrapped bunches of tomato plants are then packed in wirebound crates. The feasibility of packing the tomato transplants directly into shipping containers from a mechanical harvesting machine developed by Crops Research Division will be tested next season. New shipping containers such as wax-coated fiberboard boxes and accessory packaging materials such as polyethylene film and polyethylene film laminated to crepe paper will be tested.

11. Standardization of containers for fresh fruits and vegetables. A pilot study on the extent of use, dimensions, net weights and specifications of shipping containers used for fresh fruits and vegetables in the United States was completed under contract by the Research Triangle Institute, Raleigh, North Carolina. The pilot survey was undertaken in four warehouses, in each of the cities of Los Angeles and New York over four seasons of the year. The purpose of the study was to provide information to develop a national survey. In the pilot study 112 different size boxes were found in use for apples, 45 for grapes, and 22 for cauliflower. These examples of proliferation in sizes of containers indicate the lack of uniformity in use of containers for fresh produce.

12. Flowers.

Chrysanthemums. Twenty cents a box can be saved by packing and shipping California chrysanthemums in a regular slotted (RSC) box instead of in the conventionally used part-telescope fiberboard box. Packing labor and accessory packing materials for the RSC box were more expensive, about \$.20, but the smaller cubic space occupied by the box saved \$.40 in air freight cost. Another experimental container tested for California chrysanthemums, a foamboard (polystyrene foam sandwiched between two facings of kraft paper) costs \$.61 more than the part-telescope fiberboard box. It was presumed that the foamboard box would provide better insulation for the cut chrysanthemums than the fiberboard boxes, but all three boxes protected the cut flowers from changes in ambient temperature equally well.

Carnations. Twelve test shipments of Colorado carnations packed in fiberboard shipping containers of various designs and with various types of liners and accessory packaging materials were made during the 1966-1967 season. Stem breakage averaged about 3 percent in all of these test shipments. Container damage was not a serious problem. Minor modifications in packing these flowers offer potential savings. A wood cleat instead of metal tipped cleat is less expensive and offers potential economies. Polyethylene film laminated to crepe paper and an expanded polystyrene foam liner provided better insulation at less cost than currently used materials such as spun fiberglass blankets and air cell liner materials.

B. Packages and shipping containers for animal products

1. Poultry. Ten pounds less ice is used when poultry is ice-packed in polystyrene foam boxes instead of in wirebound wood crates. Polystyrene boxes weigh four pounds less than the wirebound crates. The polystyrene box costs more than the wirebound box but savings in packing labor and package ice offset this higher cost. Significant savings in transport cost can be obtained because a packed polystyrene box weighs about 1/4 pounds less than a wirebound box packed with the same amount of poultry. In a 40,000-

pound truckload there would be 31,850 pounds of poultry if polystyrene boxes with 15 pounds of package ice were used as compared to only 27,300 pounds of poultry when wirebound boxes with 25 pounds of ice are used. It is estimated that in the U.S. 5,179 million pounds of poultry per year are shipped in wirebound boxes with about 25 pounds of package ice and that the average distance that this poultry is shipped from processing plant to market is 500 miles. With a truck operating cost of 36 cents per mile, the cost of a 500-mile truck shipment would be \$180 and the saving in transport cost would amount to 9.4 cents per 100 pounds of poultry shipped -- a potential saving of 4.9 million dollars if all 5,179 million pounds of poultry shipped in wirebound crates were shipped in polystyrene boxes. Laboratory tests showed less carcass weight loss and lower microbial counts for the poultry packaged in polystyrene foam boxes than in wirebound crates.

2. Milk. A manuscript on costs for packaging and handling fluid milk in plastic packages is being prepared.

C. Packages and shipping containers for overseas markets

1. Fruits and Vegetables.

Four test shipments of apples were made from Portland, Oregon, to Stockholm, Sweden. The apples, Golden Delicious, Red Delicious and Newtons were shipped in tray-pack boxes and cell-boxes, each holding about 42 pounds, and in 4 cell pallet boxes holding about 800 pounds. Some tray-pack and cell-pack boxes of apples were handled individually, and some were handled unitized on pallets. Data developed in these tests indicate that palletization of boxes offer savings of \$1.00 per 100 pounds. Packing, handling, and transporting the apples in the 800-pound 4 cell pallet box instead of in 42-pound boxes handled individually offers savings of \$2.58 per 100 pounds. In these shipments to Stockholm there were no significant differences in the amount of bruising of apples packed in the different containers and handled individually or unitized.

Rutgers University completed a contract studying the feasibility of packing and shipping cell-pack Golden Delicious and McIntosh apples in a 30 by 50 cm. box--one of the proposed European standard containers. McIntosh apples and Golden Delicious apples packed in cell boxes with 30 by 50 cm. outside dimensions did not show any more bruising than comparable apples packed in conventionally used cell-pack boxes in test shipments made from apple producing areas to New York City. The tests indicate that the packing of all the sizes of apples of these two varieties that are exported in one dimensional size cell-box would increase the costs of placing apples in Europe about 1/2 cent per pound.

2. Poultry. The cost of shipping frozen poultry in van containers to Europe can be reduced by using cheaper lighter weight shipping containers and by elimination of metal strapping. Two van containers loaded with frozen turkeys were shipped from Virginia to Germany. The lower cost, 200- and 250-pound test board fiberboard boxes, performed adequately and they cost 3.5 and 2.0 cents less respectively than the commonly used 275-pound box. The non-strapped box arrived in Europe in as good condition as the box strapped with one or two metal straps. Elimination of two straps saves .4 cents per box. Receivers want at least one metal strap to reduce pilferage while the boxes are being distributed from the receiving points to retail stores.

PUBLICATIONS REPORTING RESULTS OF USDA  
AND COOPERATIVE RESEARCH

Shipping Containers and Packages for Fresh Fruits and Vegetables

Nicholas, C.J., and Risse, Lawrence A. January 1967. Containerized Turkey Shipping Cuts Its Teeth. Poultry Meat.

Fountain, James B., and Chapogas, Peter G. November 1966. Prepackaging Pears at Shipping Point. MRR-758.

Hale, Philip W., and Hinds, Jr., R.H. October 22, 1966. Better Packaging and Transport for Overseas Shipments of Peaches. The Packer.

Hinsch, Robert Tom. October 1966. New Overwrapped Trays for McIntosh Apples. ARS No. 52-16.

Mallison, Earl D., and Spalding, Donald H. October 1966. Use of Ozone in Tomato Ripening Rooms. ARS No. 52-17.

Mallison, Earl D. July 13, 1966. Improved Shipping Containers for Peaches, a paper presented at the Northeast United States Peach Marketing Conference, Philadelphia, Pennsylvania.

## AREA NO. 8 TRANSPORT EQUIPMENT AND TECHNIQUES

Problem. The cost of transporting farm products to market in 1966 was about 5 billion dollars. Cost of transporting supplies used in farm production was more than one billion dollars. Further, costs of other marketing and production functions, such as loading and unloading vehicles, packaging, storage and processing, also are affected by the efficiency of transport. These costs are important to the American farmer because they influence the return he receives from the sale of his products. They also are important to the American consumer because they influence the price he pays for his food. Therefore, the prosperity and efficiency of our entire agricultural industry and the economic well-being of the American consumer are closely tied to the efficiency of our transport system.

In spite of the importance of transport to agriculture and the consuming public, research to make it more efficient and less costly has been meager. New advances in transport and engineering technology, including the development of new materials, new building and operating techniques for transport equipment, containerization and unitization--all offer opportunities to improve agricultural transport. Translating these and other opportunities into working advantages for our agricultural producers and consumers requires a strong program of economic-engineering research. Such a program will help increase returns to American farmers, provide better products at lower costs to American consumers, and improve the competitive position of our farm products in foreign markets.

### USDA PROGRAM

The economic-engineering research in this field is a long-range program. It seeks to develop improved transport facilities, equipment and techniques and more efficient ways of using them in transporting agricultural products and supplies. It is interdisciplinary in nature, drawing upon the training and experience of economists, mechanical and industrial engineers, marketing specialists and various other scientists. All the work is done with the cooperation of transport firms, transport and refrigeration equipment manufacturers and lessors, trade associations, State universities and experiment stations. Field studies are carried out throughout the U. S. and on overseas shipments. Only one field station, Orlando, Florida, presently is maintained to support this research program. Part of the work is accomplished through research contracts and cooperative agreements.

At the present time, work is underway in each of the following fields: (1) Transport equipment, (2) refrigeration equipment and techniques, (3) better utilization of transport equipment and techniques, (4) loading methods, including unitized and palletized loading, and (5) overseas transport.

This program of research involves 12.0 scientific man-years apportioned as follows: Fruits and vegetables 3.8, animal and animal products 1.0, floral products 0.8, grain and forage 0.8, and overseas transport of fruits and vegetables 2.8, animal and animal products 1.1, and poultry and poultry products 1.7.

#### REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

##### A. Transport Equipment

1. Multi-Purpose Transport Vehicles. Van container design and development--Work on the design and development of a multi-purpose van container system, to reduce the costs of intermodal transport and handling of perishable and non-perishable agricultural products was continued during the year. Research under contract with the General American Transportation Corporation, begun in July 1966 and completed in March 1967, covered the building and testing of a 10-foot long mock-up section in a 40-foot van to evaluate the air circulation system. Excellent rates of airflow were obtained through the refrigeration coils, down the sidewall air plenums, across the floor and upward through a simulated floor load. These results indicated that the sidewall air plenums and floor channels were of sufficient size for the job. Another favorable result was the finding that it may be possible to reduce the capacity of the electric air blower motors from one-fourth to one-eighth horsepower with a consequent savings in cost and power requirements. Work also was begun late in the year on the building of a 40-foot long prototype multi-purpose van container for studies to measure the van's thermal efficiency. Completion of this research is scheduled for January 1968.

The Maritime Administration of the Department of Commerce contributed \$10,000 to help test and evaluate the multi-purpose van container system. The Maritime Administration is interested in having the van container developed and used to help increase the efficiency of the United States Merchant Marine. The funds were made available under a reimbursable agreement with the Office of Research and Development of the Maritime Administration.

Trailer Conversion Systems--A research report on the results of work completed last year has been revised and is being reviewed for publication. The report covers the development of conversion systems for closed trailer vans to enable transport of dry bulk cargo in closed trailer vans originally designed for transport of packaged cargo only. The conversion systems, which can be installed in vans already in service, reduce transport cost by making it possible for the truckers to carry payloads in both directions. The conversion systems also help reduce handling costs because they permit mechanical loading and unloading of the bulk products. One of the conversion systems makes possible transport of granular products such as grain and pelletized feeds, other products in bulk such as potatoes and apples in refrigerated and non-refrigerated vans. Another system can be used to make dry cargo vans adaptable for transport of dry flowable products such as flour which requires pneumatic loading and unloading. Many trailers in the Pacific Northwest are now equipped with the conversion systems. This work was done in cooperation with the Oregon Agricultural Experiment Station.

Work also continued during the year on the development of a conversion system to enable transport of bulk liquid cargoes in closed trailer vans. Large collapsible, rubber-coated fabric tanks with disposable plastic film liners were developed last year for transport of liquids in closed trailer vans. A new method for bleeding the air trapped between the disposable film liner and the rubber tank during inflation while loading was developed to correct problems encountered in earlier tests. The tanks are already being used by one chain store in the Pacific Northwest to transport 4,500 gallons of milk to its processing plants after delivering groceries to a number of supermarkets near milk producing areas. Other cargoes being transported in the tanks included grape juice and liquid sugar. This work also is being done in cooperation with the Oregon Experiment Station. A report on the results of this work will be prepared during the coming year.

2. Flower Transport. Research was continued on transport and handling of carnations. The objective of this work is to seek ways of lowering the cost of transport and physical distribution and to deliver a better product to the consumer. Improvements appear possible in two areas. One is maintenance of flower temperature in transit and the other is distributing the carnations in the bud stage instead of as open flowers.

Ten air transport tests of carnations were made from Denver, Colorado, to Eastern destinations during the year. Flowers averaged about 54° during distribution, or 20 degrees above the desired temperature of 34°. Aircraft cargo compartments were held in the range of 50° to 65° and air transport accounted for about 20 percent of the total time the flowers were in transit. During the other 80 percent of transit time accounted for by ground transport and handling there was no control of ambient temperature. From the tests it appears that, for the foreseeable future, temperature of flowers moving by air will have to be maintained by means of a coolant inside a properly insulated carton, rather than by equipment and facilities in which the flowers are held or transported. A promising possibility of reducing the cost of transporting and handling carnations is shipping the flowers in the bud instead of open flower stage, with flowers to be brought to the bloom stage by the destination wholesaler or retailer. In the last three of the air transport tests, carnations were shipped by both methods. These preliminary tests indicate a possible saving of over one million dollars per year with a bud distribution system. Further tests and analysis of possible economies will be made in the coming year.

3. Grain Transport in Boxcars. An analysis was made of grain losses and car defects in 1,989 boxcars of wheat, corn, and soybeans inspected at unloading points in Kansas City, Minneapolis, and Chicago. The objective was to measure the amount of grain loss from various causes during transport.

Information was obtained on the condition of the grain doors, presence of holes in the car floor, presence of grain trapped behind defective car walls, presence of grain leads, condition of the interior of the car, amounts of grain left in cars after unloading, and grain samples removed from cars.

Grain taken for samples averaged 7 pounds a car. Grain left in the cars after unloading in 94 percent of the cars was 28 pounds per car. In 8.6 percent of the wheat cars, losses of 804 pounds per car resulted from holes in the car floor and defective walls, while data for those losses in corn and soybean cars were inconclusive.

There appears to be need for two other improvements. One is a new type of grain door which would require fewer nails for installation, thereby causing less damage to door posts and adjacent areas in the car. Another is more accurate weighing practices at origin to help industry to obtain a clearer picture of losses.

#### B. Transport Techniques

1. Overseas Transport. Three container van loads of fruits and vegetables from Texas and Florida shipped to West Berlin for exhibit and sale at the Green Week Food Fair were studied during the year. Included in the shipping experiments were one van load of pink grapefruit and one van load of one-pound film bags of carrots from the Rio Grande Valley in Texas and one van load of mixed vegetables from Florida, consisting of celery, radishes, Chinese cabbage, romaine, endive, and Boston lettuce. All three test shipments arrived with no losses from pilferage or physical damage. Because of sufficient pretransit cooling of the vegetables, periodic exchange of air in the van load of grapefruit to prevent the accumulation of harmful concentrations of carbon dioxide, and adequate refrigeration in transit, all products were delivered in good condition. Transport and handling costs were obtained for all three shipments from packing plants as far as Rotterdam. However, cost data for land transport to West Berlin are not yet complete.

Researchers assisted shippers in loading the vans and in making arrangements for protection of the products during transport and handling. The research was conducted in cooperation with the Market Quality Research Division, ARS, the Texas Farm Bureau and the Florida Fresh Fruit and Vegetable Association. More tests are planned during the coming year to gather data on condition of shipments and transport and handling costs. Following the first experimental shipment of Texas pink grapefruit, an additional 35 van loads were shipped to Europe on a regular commercial basis.

Shipping experiments also were made with containerized shipments of Florida sweet corn to West Germany in mechanically refrigerated trailers. Transport researchers provided supervision during loading to insure proper stacking, sorting and icing of the loads. Air and product temperatures were taken during the domestic portion of the trip. Data on icing and re-icing to provide adequate cooling and moisture for the product were obtained. While the corn arrived in good condition, the test results were inconclusive. In the two trailer loads, the crushed ice placed on top of the load was melted completely before the trailers arrived at Norfolk, Virginia, for loading aboard ship. Observation of the operation of the trailers' refrigeration systems showed that the rapid rate of ice meltage was caused by the mechanical refrigeration units being periodically switched on to the heating cycle by their thermostatic controls. Work is being continued to solve this problem

by modifying the thermostatic controls of the refrigeration units. The research is being done in cooperation with the Fruit Growers Express Company, owners of the trailers, refrigeration equipment manufacturers, the railroad and shippers.

In cooperation with the Florida Citrus Exchange, four container shipments of grapefruit to Paris were studied. The vans were transported by piggyback to New York where they were transferred to a high-speed containership bound for LeHavre. Transport researchers assisted shippers in loading the vans and in making arrangements for protection of the products during transport and handling. Although about one-fourth of the boxes were poorly closed, the shipment arrived in Paris with no losses from damage and pilferage. Savings on ocean freight costs because of a 10 percent discount in ocean freight rates for container shipments were 11.5 cents a box, or \$146.80 per van. Savings in cargo insurance also amounted to \$4.70 per van load. Work on an interim report on transporting fruits and vegetables to overseas markets was begun during the year.

Redesigning of a marine hatch plug to prevent sea water from entering ventilation hatches in container vans carried on the decks of containerships was completed during the year. In stationary tests using the ventilation plug in conjunction with a one-horsepower electric driven exhaust fan good rates of airflow were obtained in 40-foot long vans. Transport tests with grapefruit shipments to Europe to further evaluate the ventilation will be made early in the coming year.

Research with shipments of frozen poultry to overseas markets to develop better and lower cost methods of transport and handling the products was accelerated during the year. Eight test shipments of poultry, four by van container and four by the conventional break-bulk method were made from points in Virginia, Georgia, and Iowa to markets in Germany, Italy, and Greece. Three of the shipments were paired for the purpose of comparing transport costs by van container with those by the usual break-bulk method. Data on transport and handling costs were gathered from shippers' packing plants to the consignees' warehouse overseas. For some shipments, total transport and handling charges were less for the van container shipments than for the break-bulk shipments. In other instances transport charges were lower for the break-bulk shipments than for the van container shipments. The lowest cost transport method studied was a break-bulk shipment of 1,500,000 pounds of whole broilers from Georgia to Greece by a chartered refrigerated ship through the port of Charleston, South Carolina. Losses from container damage and pilferage were much lower for the containerized than for the break-bulk shipments. Product temperatures during transit were as much as 30 degrees lower in the containerized shipments than in some break-bulk shipments. The research is being continued to develop labor and capital inputs and for more accurate measuring of transport and handling costs. An interim report on the results of this work was begun during the year.

A pallet container for shipping breeding swine overseas in jet cargo planes which allows the animals to be handled with the same efficiency as other cargo also was developed. One test shipment was made using three containers

to transport both pigs and hogs to Italy. The time required to handle and transport the animals was 2 days as compared to 2 to 3 weeks by sea. The container can be disassembled, cleaned and reused or disposed of, whichever is most advantageous. Suggested design features for an aluminum livestock pallet container were given to the Reynolds Aluminum Company who built and tested a prototype in the same test shipment with the USDA container. The aluminum container also can be reused.

The feasibility of using turkey crates as containers for shipping feeder pigs by air also was explored. Preliminary tests were made in Beltsville and a test shipment was made transporting pigs in turkey crates to Nigeria. The crates are low in cost and can be stacked on pallets for large shipments or used in small shipments carried in the cargo compartments of the airplanes.

An air cargo pallet rack made of aluminum and steel pipe for hanging beef was designed, constructed and tested in a laboratory. The rack was covered with a disposable insulated paper blanket and loaded with ten hindquarters of beef with dry ice for refrigeration. A 24 hour stationary test to simulate handling and transit times for overseas flights was made. The test showed that disposable insulating materials can maintain desired product temperatures. Also tested were two types of insulated boxes for less-than-pallet-load shipments of beef. One box was fiberboard insulated with a paper blanket and the other was made of plastic foam. The tests showed that both types of boxes give about the same protection to the product and that they should protect fresh meat products in transit overseas, if certain precautions are followed.

2. Unitized Loading. Exploratory research to determine the feasibility of developing more efficient, lower cost methods of unitizing consumer size bags of potatoes was begun during the year. Specifications for a feasibility study to be done under contract were prepared. Food Industries Research and Engineering, Inc. of Yakima, Washington, was selected to do the research. The study will determine, from both the engineering and cost standpoints, the feasibility of unitizing, automatically and semi-automatically, 10-pound bags of potatoes. The unitized methods to be studied are intended to be used in place of manually-packed 50-pound multi-wallpaper bags now used as master containers for transporting and handling the 10-pound bags. If the present material and labor costs of unitizing the 10-pound bags can be cut in half, the savings would be about a million dollars a year. It also is expected that other advantages, such as improved product ventilation and reduced transport, storage and handling costs will be gained from use of better unitizing methods. If a feasible unitizing system can be developed for the large volume of fresh potatoes now packed and shipped in consumer size bags, it may also be used for onions, carrots, turnips and a number of other products now packed and marketed in the same way.

Some exploratory work on the feasibility of developing expendable and non-expendable plastic pallets for unitized transport and handling was done during the year. Information on the availability, costs, and specifications of other types of expendable pallets also was gathered. Other data required for planning shipping and handling experiments with palletless and palletized transport also were obtained.

3. Improved Loading of Bagged Onions. The purpose of this research was to find ways to improve load stability and increase air circulation in shipments of bagged onions during transport. Different load patterns for the bags and new cushioning materials which might help to reduce container and product damage were evaluated. New stacking patterns for both rail and truck shipments to provide better air circulation through the loads have been developed. The new patterns provided numerous vertical air channels which extend from top to bottom of the loads in rail cars and from the front to rear of trailer loads. Better circulation of incoming air through the load helps remove excess heat and moisture, and the development of decay. This was accomplished with no reduction in the number of bags in each shipment by increasing the height of the load.

The field work and much of the manuscript reporting the results were completed at the beginning of the year. During the year the data were further tested for statistical significance and extensive revisions were made on the manuscript. The report will be published and the project terminated during the coming year.

4. Pallet Containers For Transport of Apples. This research sought ways to reduce container, packing and transport costs by shipping and handling apples in pallet containers to terminal market prepackaging plants. Savings from use of pallet containers for this purpose instead of the conventional 40-pound corrugated fiberboard boxes were found to range from 0.1 cent a pound, or about \$150 a carload for one trip to 0.2 cents a pound, or about \$300 a carload when the pallet containers were used for two trips. The savings result from lower container, packing, handling, freight and refrigeration costs when pallet containers are used. The report on this research was extensively rewritten during the year. It will be completed and the project terminated in the coming year.

5. Heavier Loading of Watermelons. Results of this research showed that savings in railroad out-of-pocket costs of transporting watermelons from southeastern producing areas to northern markets would have been more than \$170,000 a year if the melons had been loaded 7 layers high instead of the conventional 5 layers high. The research also showed that about \$7,000 in cost of material used to cushion the melons in rail shipments could be gained from heavier loading. Although there were more damaged melons in the heavier loaded cars than in the lighter loads, the increase in the amount of damage was not related to the increase in load height. Studies comparing the effectiveness of expanded polystyrene foam and straw for cushioning the melons in rail cars showed no significant difference in the amount of melon damage, but the foam had some advantages such as cleanliness, ease of application and helping make possible better ventilation in the loads during transit. The results of this research are reported in ARS 52-22, "Heavier Loading of Watermelons in Rail Cars and Piggyback Trailers."

PUBLICATIONS REPORTING RESULTS OF  
USDA AND COOPERATIVE RESEARCH

Transport Equipment

Guilfoy, R. F. September 1966. Perishables Shipping. A paper presented at the 7th National Food Distribution Research Conference, Newark, Delaware.

Ashby, B. H. May 1967. USDA Has Some Answers, Will Develop Others For Perishables. Air Cargo.

Transport Techniques

Nicholas, C. J. and Risse, L. A. August 1966. Containerized Shipping as a "Cheaper" Method. Poultry and Eggs Weekly.

Clayton, J. E., Breakiron, P. L. and Goddard, W. F., Jr. August 1966. The Omniferent Container, Handling and Shipping.

Nicholas, C. J. October 1966. New Transport Techniques and Containers for Shipping Frozen Poultry to Overseas Markets. Paper presented at the National Poultry, Butter and Egg Association Annual Convention. Chicago, Illinois.

Nicholas, C. J. and Risse, L. A. November 1966. Containerized Shipping of Frozen Turkeys to Italy. Poultry Meat Magazine.

Nicholas, C. J. January 1967. The Marketing of U. S. Frozen Poultry in Europe. Taped interview and discussion on the USDA program "Across the Fence" for broadcast on 25 NBC-TV stations.

Breakiron, P. L., Nicholas, C. J. Stewart, J. K., and Kurtenacker, R. S. January 1967. Reducing Transport Damage in Top-Iced Shipments of Fresh Vegetables in Bushel Baskets. (A Study of Rail Shipments of Fresh Peas). MRR-772.

Clayton, J. E. April 1967. What's Ahead in Containerization. Paper presented at the Agricultural Policy Institute Conference: Transportation and the Changing South. Raleigh, N. C.

Clayton, J. E. May 1967. Need Van to Haul Fresh Food Overseas. Container News.

Black, W. R. and Breakiron, P. L. May 1967. Heavier Loading of Watermelons in Rail Cars and Piggyback Trailers. ARS 52-22.

Clayton, J. E. June 1967. Van Movements Reduce Spoilage. Container News.

Clayton, J. E. January 1967. Containerization Research by the U. S. Department of Agriculture. Paper presented at the Seventh Annual Conference. Containerization and Packaging. New York, New York.

#### AREA NO. 9 RETAIL FOOD STORE OPERATIONS

Problem. There are about 300,000 food retailing establishments in the United States which market over two thirds of all farm products, representing nearly \$76 billion of sales. This is an increase in sales of 7 percent over the previous year. The corporate chains had a 41 percent share of total U. S. grocery store sales in 1966 compared to 41 percent in 1964. Voluntary and cooperative independents had a 51 percent share of total sales in 1966 compared to 50 percent in 1964.

Research in improving efficiency of retailing, while very limited in scope, has been effective. However recent trends in the industry require expansion of research efforts if food costs are to be held down. Costs for wages, representing about half of retail operating expenses, have risen rapidly. Costs for construction, equipment, materials and real estate are rising. The number of items carried per store has increased, lowering the individual product volume and adding to unit costs. Customers per store and sales per square foot have been lowered by competition. Therefore, rising costs are no longer offset by increasing efficiency. The Food Marketing Commission pointed out several examples of inefficiencies in handling of food; bread and milk distribution, rack service for foods such as crackers and cookies, and lack of central meat and produce preparation. Each of these areas represents current or recent research by the Wholesaling and Retailing Research Branch. These major changes in operating techniques, along with others being studied or planned such as central grocery pricing and distribution systems analysis, offer the most economical methods by which food store margins can be reduced or held down. Most firms are too small to afford expensive research or trial and error experimentation. Others need to be shown that research is effective. Independent food stores have shown they can operate at low costs when provided the research and extension assistance through the use of facilities, personnel and funds. However the complexity of the problem is such that a considerable effort is needed now in the face of rapidly rising costs.

#### USDA PROGRAM

The Department has a continuing long range program of research utilizing marketing specialists, engineers and personnel with other skills to develop improved work methods, equipment, materials, layout and operating procedures for retail food firms. This work is carried on an informal cooperative basis with Federal and State extension services, other governmental agencies, state departments of markets, trade associations, and with members of private industry. The program includes the utilization of various means of disseminating the information to the separate firms by such tools as motion pictures, clinics, speeches, and similar means. The federal scientific man-year effort devoted to this research in 1966-67 totaled 1.7 years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Meat

1. Packaging and price-marking meat and poultry in retail food stores. This project is designed to develop new and improved work methods, equipment, materials, layout and operational practices for packaging and price-marking in retail meat departments.

A Marketing Research Report No. 773, entitled "Systems and Equipment for Packaging and Price-Marking Meat and Poultry in Retail Food Stores" was released in January 1967. In this report a cost comparison was made of five methods of wrapping, weighing, and pricing retail cuts of fresh meat in retail food stores' meat backrooms. A mathematical breakeven formula was developed and is presented in the report to aid industry to use their particular labor, equipment and material costs in evaluating meat wrapping systems that they might be considering installing in their meat backrooms.

2. Improved display and customer service for meat and poultry products in retail food stores. The purpose of this research is to improve display handling, equipment and layout for retail meat departments through improved work methods, improved display equipment and better management practices in order to reduce costs and encourage increased volume for fresh meat and poultry.

A study was conducted in a Washington, D. C. supermarket to evaluate the productivity and effect on sales of alternate techniques of displaying fresh meats in the retail store display cases. The data are currently being analyzed. It is planned to collect additional inventory and movement data in meat departments of retail food stores to determine the most efficient methods and procedures for displaying meat and poultry products.

3. The effect of improved techniques of sanitation and temperature control in retail processing of meat. The purpose of this research was to determine if the shelf life of retail cuts of fresh meat could be substantially extended by using optimum temperature and sanitation procedures. This project is being conducted in part through a contract with the University of Missouri, jointly administered by the Market Quality Research Division and the Transportation and Facilities Research Division of ARS.

Two technical reports summarizing the laboratory work and the field work are now being prepared by the University of Missouri. In addition a major meat packer was supplied the necessary funds to Super Market Institute to prepare a color, sound motion picture of the results of this research. Work on the film is now underway with the cooperation of the Federal Extension Service.

B. Produce

1. Preparation and packaging of produce at the central warehouse. The purpose of this project is to improve and evaluate the cost of central warehouse produce packaging and to make comparisons with other locations for produce packaging. Previous research under this project concerned with bagged produce items has been published in MRR No. 721, entitled "Packaging Produce at the Central Warehouse" and ARS report 52-7, entitled "Packaging Produce at the Central Warehouse--Bananas." A third manuscript originally entitled "Guidelines for Tray Packaging of Produce at the Central Warehouse" has been completely revised to include detailed cost analyses of tray packaging at the store and tray packaging at the warehouse.

The fresh produce industry is a \$5 billion business at retail and about 40 percent of this volume is sold in completely prepackaged produce departments annually. Presently about 700 million packages of trayed produce are sold annually in the United States.

The lowest cost method at the store was using a polyvinyl chloride stretch type film with a full overwrap of the tray. This method cost 7.23 cents per package including labor, materials, equipment and overhead charges. At the warehouse items were completely overwrapped with a two-way shrink type polyvinyl chloride, with the exception of green beans which were overwrapped with a polystyrene two-way stretch film. Trays were used for all items except for beans and grapes on which a folding box was used.

The warehouse operation, including labor (both direct and indirect), materials, equipment, overhead, container costs and loss of trailer capacity, costs 4.51 cents per package. A savings of 2.72 cents per package compared with the lowest cost store method.

This research indicates that tray packaging the 700 million packages at the warehouse rather than by the lowest cost method at the store would produce annual savings in excess of \$19 million. The report on this research "Packaging Produce at the Central Warehouse-Trayed Items" is undergoing final revision and should be released in 1968.

C. Bakery

1. Improved retail bakery department methods and practices. The purpose of this research is to increase the efficiency of retailing bakery goods through the analysis and development of improved methods, procedures, equipment, materials and layout and to compare the operating costs of bake-off bakery departments with conventional on-premise bakery operations.

The emergence of the modern supermarket has resulted in many innovations in the retailing of bakery products. One of the most significant changes has been the development of the complete bakery department where some type of in-store baking is used to supplement the commercial baked goods section.

The two most prominent in-store baking systems, on-premise and bake-off, were analyzed to identify the cost structure of each. An on-premise bakery is a system where products are mixed, formed, baked, and finished for sale on the store premises. A bake-off bakery is a system where most products are mixed at a central bakery, frozen, and then delivered to retail food stores where they are formed, baked, and finished for sale.

A detailed costing study of high and low volume on-premise and bake-off bakery departments has been made. In addition, supporting data were obtained from 75 additional retail bakeries as a basis for evaluating the selected case studies. Budgeting techniques and labor time studies were used to project the two bakery systems to comparable volume levels. A product mix was selected which represents approximately 90 percent of the product categories produced in the average retail bakery.

Preliminary results reveal the bake-off operation to be the cheaper from a labor and overhead standpoint. The final analysis of the two systems will be completed during the coming year and a comparison of the two systems, together with recommendations for improving all retail bakery departments will be presented in a Marketing Research Report.

#### D. Store Operation and Layout

1. Increased efficiency of independently owned and operated small food distribution firms. The purpose of this research is to increase the efficiency of food retailing through the further development of research results to broaden their adaptability to stores of varying sizes, ownership control, location, and other individual characteristics with special emphasis on the superette or neighborhood type store.

Several training clinics were conducted covering such subjects as warehousing, produce, meat and grocery operations and institutional food operations. In addition educational exhibits were maintained at four national trade association conventions.

The Federal-State Extension Service cooperated closely with the Wholesaling and Retailing Research Branch in getting research results adopted by the food distribution industry. During the past year Puerto Rico and the following 18 states had active extension programs with wholesalers and retailers; California, Delaware, Florida, Hawaii, Illinois, Indiana, Kansas, Kentucky, Maryland, Massachusetts, Missouri, New Hampshire, New Mexico, New York, Ohio, Pennsylvania, Vermont and Virginia. Illustrative of the results reported during 1967 are as follows:

Delaware - Eight comprehensive 3-day management seminars were conducted with voluntary group wholesalers. The seminars had an average attendance of 55 management personnel and covered such topics as advertising, fiscal control, institutional wholesaling, sales development, retail accounting, warehouse management and store engineering.

Florida - Demonstrations of retail store layout, merchandising, operations, and customer flow were conducted for retail store managers and produce managers within the State.

Hawaii - Training workshops were held in Hawaii for food retailers on the subject of inventory control, management, merchandising, space allocations, department organization, control of dairy products, sanitation and centralized packaging of meat and produce.

Illinois - During 1966, numerous management studies were conducted with food retailing firms. The management analysis which proved to be the most fruitful was made in a small group of supermarkets. Within six months, approximately 50 percent of the major recommendations for improvement had been made.

Kentucky - Comprehensive operational and financial analyses of two food wholesaling firms were developed during the year. Information from these studies was presented at two regional Kentucky wholesale grocers' association meetings and in a comprehensive publication which was distributed to all wholesaling firms in the State.

Massachusetts - Extension specialists conducted two-day seminars dealing with managing human and capital resources more efficiently and handling and merchandising fruits and vegetables. The seminars were attended by about 50 management personnel from wholesale and retail food firms in the market area.

Missouri - Educational work was conducted with two firms with in-store restaurants. As a result of changes made based upon recommendations that were given to one of the firms, a 20 percent loss from this operation was changed to profit.

New Mexico - Interest by retail management in lengthening the case life of fresh meats was stimulated in New Mexico by a series of beef marketing workshops conducted by Extension specialists. The dollar savings when the ARS research results are employed were persuasive with retail management.

Ohio - Assistance is being given to management of a chain group for converting to a central meat cutting and packaging operation utilizing information from USDA research. If these centralizing efforts can be successfully completed, it will be a significant breakthrough in meat distribution in Ohio and represents potential savings of million of dollars.

Pennsylvania - An educational program to aid retailers in adjusting to the State's frozen food code was extended to many food firms within the State. These meetings assisted those responsible for frozen foods to utilize more efficient methods of handling, receiving, storage, and displaying and to comply with the frozen food code.

Puerto Rico - Educational assistance was provided the management of consumer cooperatives to aid in the remodeling of their retail stores. The remodeling increased sales volumes for the stores. Specialists also conducted educational programs with a voluntary group of food retailers. Layout plans were prepared, and intensive orientation was given on appropriate equipment, inventory control and modern merchandising techniques.

2. Optimum work methods, equipment, layout and store organization for the total retail food store. The purpose of this project is to increase the efficiency of the entire food store operation by combining through the use of operational research techniques the results of past research developed in the various departments of the store. A research agreement with Ohio State University to reprogram the existing produce model of retail food store operations and conduct tests of these standards was delayed but is now being developed into a working program on modern computer components. Tests with actual store data will begin this coming year. Also meat standard data collected by USDA and Ohio State on cutting, wrapping, weighing and pricing retail cuts of meat are being merged by Ohio State to provide industry with more complete operating standards.

Under a research agreement to evaluate the low cost retail store Purdue University has developed a bibliography and is analyzing 464 store records now on hand to determine the key factors in low cost operation. Additional data will be obtained from low cost stores to determine what factors in retail operations result in low prices, low margins and low expenses.

#### E. Systems Model of The Beef Industry

The purpose of this project is to study the use of "systems models" to pretest improved methods of distributing meat. Fresh beef has been selected as the test product and a contract let with the A. T. Kearney & Company, Inc. to determine the feasibility of an operations research approach for assembling all the marketing functions into an optimum cattle and beef marketing system. Past USDA research data and industry information would be used to calculate lowest cost combinations of functions or techniques. Such a model could be used to: (1) guide the research efforts of the various groups in the Department of Agriculture toward areas having the greatest potential for improvement of the system; (2) evaluate and demonstrate the overall benefits to be gained from improvements in individual components in the total processing and distribution system; (3) develop a better understanding of the meat distribution system and of the interplay of forces within the system; (4) furnish guidance and counsel to small and medium size meat processors and

distributors to show them the value of improved methods and alternative approaches to increasing their efficiency; and (5) enable individual companies to relate their own specific capabilities to the entire meat distribution system.

In addition, a committee has been formed of Division specialists in various phases of meat distribution and with the help of industry groups to "inventory" the possible changes in beef handling and distribution. This "inventory" will provide a basis for determining the possible tests that may be made with beef systems models and should provide a better understanding of the changes expected in this industry.

PUBLICATIONS REPORTING RESULTS OF  
USDA AND COOPERATIVE RESEARCH

Meat

Volz, Marvin D. January 1967. Systems and Equipment for Packaging and Price-Marking Meat and Poultry in Retail Food Stores. Marketing Research Report No. 773.

Anderson, Dale L. March 14, 1967. Recent Developments in the Handling of Fresh Meat Including the Experience in Europe. Meat Handling Seminar. Washington, D. C.

Anderson, Dale L. June 4-7, 1967. Operating Problems and Innovations in the Distribution of Meat. Super Market Institute. Cleveland, Ohio.

Volz, Marvin D. March 14, 1967. The Techniques of Central Meat Cutting. Meat Handling Seminar. Washington, D. C.

Volz, Marvin D. February 1967. Analysis of Meat Wrapping Systems. Paper presented at the New York Clinic for Retailers by the New York Department of Agriculture and Markets.

Produce

Anderson, Dale L. 1967. How to Cut Costs Through Better Handling and Layout. Super Market Institute Regional Produce Meetings in Boston, Mass., Pittsburgh, Pa., Portland, Oregon, and Kansas City, Mo. during February and March.

Karitas, James J. February 1967. Central Warehouse Produce Packaging. Paper presented at the New York Clinic for Retailers by the New York State Department of Agriculture and Markets.

Bakery

Doordan, Martin L. April 2-4, 1967. On-Premise Bakeries Vs. Bake-Off Operations. Tenth Annual Delaware Conference on Food Distribution. University of Delaware, Newark, Delaware.

Store Operations and Layout

Anderson, Dale L. March 8, 1967. Efficiency in the Backroom. National-American Wholesale Grocers' Association 61st Annual Convention. New York.

Volz, Marvin D. April 2-4, 1967. Cost Cutting Ideas for Pricing and Stocking Groceries. Tenth Annual Delaware Conference on Food Distribution. University of Delaware. Newark, Delaware.

Volz, Marvin D. February 1967. Work Simplification. Paper presented at the New York Clinic for Retailers by the New York State Department of Agriculture and Markets.

Volz, Marvin D. February 1967. Principles and Guidelines for Total Store Layout. Paper presented at the New York Clinic for Retailers by the New York State Department of Agriculture and Markets.

Karitas, James J. February 1967. Evaluating Grocery Handling Systems. Paper presented at the New York Clinic for Retailers by the New York State Department of Agriculture and Markets.

Karitas, James J. February 1967. Work Scheduling for Supermarket Personnel. Paper presented at the New York Clinic for Retailers by the New York State Department of Agriculture and Markets.

Karitas, James J. February 1967. Profit and Loss Statements and Balance Sheet Analysis for Retail Food Firms. Paper presented at the New York Clinic for Retailers by the New York State Department of Agriculture and Markets.

Hoecker, R. W. November 27-29, 1967. Recent Developments in Store Engineering. National-American Wholesale Grocers' Association Store Engineering Conference. Atlanta, Georgia.

#### AREA NO. 10. WHOLESALE FOOD OPERATIONS

Problem. More than 7,000 grocery and perishable food items are handled through modern integrated warehouses supplying retail food stores. Wholesaling requires an estimated 6 percent of the consumer's dollar and along with retailing, constitutes about 50 percent of the cost of marketing food. Effective wholesaling reflects itself not only in lower wholesaling costs but also in lower consumer prices. The efficiency of warehouse handling and delivery of groceries, produce, meats, and frozen foods, and of warehouse office procedures, can be increased by the development and adoption of improved work methods, equipment, layout, and organization. Research is also needed to develop coordination and improved materials handling methods between manufacturers and warehouse distributors. The need for research in these areas is accelerated by increasing wage rates and technological advances. The operating problems in the modern integrated warehouse are becoming increasingly complex due to the increased number of items handled by the modern supermarket; the increased proportion of products that are being handled through the central warehouse; and the increasing amount of preparation for sale and pricing at the central warehouse. Increased efficiency will help reduce the costs of warehousing and delivery operations; improve the quality of the product sold; help the independent operators compete with the corporate chains; increase the returns to producers; and help hold down food costs of consumers.

#### USDA PROGRAM

This is a long-term program of operational-type research, incorporating industrial engineering and marketing research techniques, designed to increase the efficiency of distributing food products at the wholesale level. It may be broadly divided into four areas of activity: (1) Grocery warehouse operations; (2) perishable products warehouse operations; (3) cost control and office procedures; and (4) total warehousing operations. Research in the grocery warehouse is concerned with improved warehouse layout, equipment, and work methods. The perishable warehouse operations research is designed to develop improved layout, work methods, and equipment to reduce the cost of handling produce, meats, dairy and delicatessen, and frozen foods through the warehouse and in delivery operations. Research on cost control and office procedures includes work designed to increase the efficiency of order taking, accounting, and inventory control. Research on total warehousing operations includes work related to total facility design, layout and work methods as well as combined loading of delivery trucks with perishable and nonrefrigerated products. The program includes use of such tools as motion pictures, clinics and speeches. Close working relations are maintained with the cooperative Federal-State Extension Service where specialists in numerous states are active in disseminating research.

The federal scientific man-year effort devoted to this research last year totaled 1.5 and of this number .3 was devoted to grocery warehousing and delivery, 0.9 man-year was devoted to produce, meat, and frozen food warehousing, .1 man-year was devoted to wholesale warehouse cost control and office procedures, and .2 to total warehousing operations.

#### REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

##### A. Grocery Warehouse Operations

1. Adhesive labels for price-marking cases. A study was completed on the evaluation of the use of adhesive labels for price marking cases in the warehouse during order assembly. Findings of the study were published in ARS 52-23 entitled "Use of Adhesive Labels for Price Marking Cases at the Grocery Warehouse." The system costs less than half as much as placing the retail price on the case in the backroom of the store. This saving of only  $\frac{1}{2}$  cent per case could amount to \$22 million annually, if applied to all the groceries sold in retail food stores. By the end of the year more than 100 large distributors reported adoption of the method.
2. Central warehouse pricing. Research was conducted during the past year to determine available equipment, potential savings, and problems that need to be resolved in the area of pricing groceries at the central warehouse. This research was conducted under a purchase order contract by the University of Delaware and the results show considerable potential savings with central warehouse pricing provided the problem of shipping half cases of groceries to the store can be resolved. A report documenting the findings of the study will be prepared during the next year.
3. Optical scanner for checking out customer orders. A memorandum of understanding was developed for evaluation of an optical scanner to be used at the retail store checkout counter. The cooperator is in the process of developing an improved scanner that will be available for testing during the fall of 1967. Substantial savings in retail store checkout labor and retail store and warehouse inventory appear to be possible if the system works as anticipated.
4. Warehousing for USDA food program. At the request of Commodity Distribution Division, Consumer and Marketing Service, a study was conducted of warehouse space and layout requirements at the regional level. The warehouse plan developed will be used to handle dry groceries and dairy products under the Division's consumer food program. A floor plan and handling methods were developed to receive, store, and issue 100 tons of food a month.

##### B. Perishable Products Warehousing Operations

1. Frozen food operations at the wholesale level. Studies were conducted in 10 frozen food warehouses of handling methods and practices. One of these studies was of a highly-mechanized operation which used four levels of

conveyors in the order selection area controlled from a computer console. A research report will be published during the current fiscal year.

C. Cost Control and Office Procedures for Wholesalers

1. Predicting item movement. A service contract has been developed with Virginia Polytechnic Institute to develop a predictive model to forecast warehouse produce item movement. The initial model will cover 10 produce items having various seasonality and storability characteristics. The objective of the study is to develop a model that will more closely predict produce item movement in order to avoid the costly over supply and under supply situations encountered by produce distributors. If the model proves to be effective it will be applied to additional produce and other perishable items.
2. Uniform financial reporting. Data was received from 51 voluntary or cooperative group firms for the years 1962 and 1963. The data was analyzed, summarized, and financial ratios developed. A report entitled "A Comparison of Financial Operating Data of Affiliated Food Wholesalers" provides the findings of the study and was published.
3. Cost of servicing various size orders. A detailed study has been initiated in four firms to determine the costs associated with servicing five order sizes for supplying retailers with groceries, produce, frozen foods, meats and dairy products. The study is being conducted to develop a method wholesalers can use to determine their own costs as well as a method for reflecting these costs in pricing products to retailers.

D. Total Warehouse Operations

1. Total warehouse layout and equipment. Initial research was directed toward a determination of the economic advantages and disadvantages of a complete distribution warehouse handling all food products compared with separate warehouses at two or more locations. Assuming that a central complete distribution warehouse proves to be economically advantageous, a layout will be developed for small, medium, and large size distributors. The layouts will incorporate the research findings being developed on ceiling height and extent to which racks should be used, and provide for orderly expansion of each part of the distribution warehouse with land and building dimensions adaptable to efficient operations. Warehouse organization, work methods and equipment will be developed and specified.

PUBLICATIONS REPORTING RESULTS OF  
USDA AND COOPERATIVE RESEARCH

Grocery Warehouse Operations

Bartz, D. J., Catel, J. M., and Bouma, J. C. May 1967. Use of Adhesive Labels for Price Marking Cases at the Grocery Warehouse. ARS 52-23.

Bouma, J. C. 1966. Research for the Food Distribution Industry. Paper presented at the NAWGA Warehouse Operations Seminar. (Published in proceedings by the National-American Wholesale Grocers' Association)

Bouma, J. C. 1966. Results of the Adhesive Label Price Marking Program. Paper presented at the NAWGA Profit Improvement and Cost Control Seminar.

Bouma, J. C. 1967. Methods of Order Selection. Paper presented at the Canadian Grocery Distributors Institute Seminar.

Hoecker, R. W. 1967. The State of the Industry. U. S. Wholesale Grocers' Association Convention. (Processed)

Cost Control and Office Procedures

Bouma, J. C. 1967. Merchandising for Better Profits and Increased Turn-over. Paper presented at the U. S. Wholesale Grocers Association Convention.

Runyan, J. L. and Bouma, J. C. October 1966. A Comparison of Financial Operating Data of Affiliated Food Wholesalers. Miscellaneous Publication No. 1031.

## AREA NO. 11. INSTITUTIONAL FOOD SERVICE OPERATIONS

Problem. Approximately one-fifth of the food consumed in the United States is distributed through institutional outlets. These outlets, including hotels, restaurants, schools, hospitals, and in-plant feeding establishments have been affected by rapidly rising operational costs and little research has been conducted for the purpose of offsetting these higher costs with increased efficiencies. Preliminary studies in food service kitchens indicate that substantial efficiencies are possible through improved work methods, equipment, layout and management practices. Research in the area of central food preparation may also substantially reduce the costs of institutional food distribution.

The efficiently operated grocery wholesalers supplying retail stores have reduced their margins since 1950 from about 12 percent to about 6 percent; however, institutional wholesalers' margins have remained at 18 to 20 percent. Although characteristics of the institutional wholesaler grocery business are such as to prevent margins of 6 percent, a realistic goal would seem to be 10 percent. It is realistic to visualize considerable savings in institutional operations from research with institutional wholesalers.

### USDA PROGRAM

This is a long term program designed to increase the efficiency of distributing food through institutional channels. It is broadly divided into two areas of activity: (1) The wholesale distributor, and (2) the food service operation. Research at the wholesale level is concerned with the improvement of warehouse layout, work methods, office procedures, delivery methods and improved services to food service operators. Food service research is directed towards increasing operational efficiency of food service outlets, including school lunch operations, through improved layout, work methods and procedures. Changes in program emphasis at both the wholesale distributor and food service levels will occur as areas of savings are evaluated.

The federal scientific man-year efforts devoted to this research totaled 1.5 and of this number 0.3 man-year was devoted to institutional grocery warehouse operations and improved services to food service operators, and 1.2 man-years were devoted to operational efficiency of food service outlets and school lunch kitchens.

### REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

#### A. Institutional Wholesale Food Distribution

1. Cost of servicing different size orders. A report, MRR-752, "Determining

"Costs of Servicing Wholesale Institutional Grocery Orders" was published in October of 1966 and has been very well received by the industry. All of the institutional food distributors associations have made this publication available to their members and over five hundred members of the National Food Brokers Association are also helping to disseminate the findings. The Pillsbury Company has made the findings known through their distributor networks and the leading trade magazine has featured this research in their publication. Principal findings of the study were reported last year.

2. Office procedures for institutional wholesale grocers. A study has been initiated to compare costs and effectiveness of various systems of order processing. This study also will include a determination of the cost and effectiveness of recent developments in time sharing of computers by small businesses. The study includes an evaluation of the influence of the various systems on warehouse and delivery operations, inventory control, accounting functions and use of byproduct information. Some work was initiated on compiling information on present systems. Work will be accelerated commencing in the second quarter of fiscal year 1968. A major food manufacturer is presently contemplating sharing the cost of this research with the Department.

B. Improved Operational Practices for Food Service Institutions

1. School lunch kitchens. A research study was completed on improved layouts, equipment, space utilization and work methods in school lunch kitchens, storage areas, and serving lines in three basic size schools having kitchen facilities on the premises. The study was published as Marketing Research Report No. 753, "Layout, Equipment and Work Methods for School Lunch Kitchens and Serving Lines." Principal findings of the study were reported last year.

2. Commercial cafeteria kitchens. Research in 12 commercial cafeterias was completed under contract by Horwath and Horwath of Washington, D. C. In this study man-hour requirements, labor utilization, work methods and layouts for two sizes of commercial cafeterias were developed. In the study it was found that labor costs averaged 32 percent of sales--an amount almost equal to the cost of the food purchased. The study also showed how labor costs can be reduced by 10 percent by improved labor utilization. Application of these findings universally would bring annual savings of \$90 million. The study also indicated that far greater savings can be made by developing improved layouts, equipment and work methods. The study was planned with the assistance of members of the research committee of the National Restaurant Association and the Association cooperated by making arrangements for the conduct of the study in selected cafeterias. A report entitled "Employee Productivity in Commercial Cafeterias" is being finalized for publication.

3. Table Service Restaurants. A cooperative agreement was developed, negotiated, and signed with the University of Delaware, Newark, Delaware, for the development of man-hour requirements, labor utilization, work methods and layouts for 12 table service restaurants. The University of Delaware will develop the man-hour requirements for each restaurant. The Department will analyze the work methods, layouts, and prepare the final report for publication. The National Restaurant Association is financing one half the cost of the cooperative agreement with the University of Delaware and, in addition, is providing contacts and transportation for the Department employee conducting the study.

4. Determination of Research Needs. A research contract has been developed, negotiated and signed with the Food Research Center for Catholic Institutions for determination and appraisal of problems and research needs in the food service industry. The study is limited to five areas, namely: (1) management, including purchasing, cost controls, sources of capital, personnel selection and training, and supplier-food service operator relations; (2) kitchen operation including layout, equipment and work methods; (3) customer service and merchandising; (4) economy of scale on efficient business size and site selection; and (5) central food preparation, commissary operations, and transportation from commissary to food service operation. One half of the contract cost is being paid under cooperative agreement by the National Restaurant Association. Research will be completed under this project during fiscal year 1968.

#### PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

##### Institutional Wholesaling

Bouma, J. C. 1967. Savings in Institutional Wholesale Delivery Costs. Paper presented at the U. S. Wholesale Grocers' Association Convention.

Hoecker, R. W. 1967. Trends in the Institutional Wholesale Distribution Industry. Paper presented at the U. S. Wholesale Grocers' Association Convention. (Processed)

Karitas, J. J. October 1966. Determining Costs of Servicing Wholesale Institutional Grocery Orders. Marketing Research Report No. 752.

##### Improved Operational Practices for Food Service Institutions

Biedermann, K., Wilhelmy, O. Jr., Dull, M. R., and Bouma, J. C. December 1966. Layout, Equipment, and Work Methods for School Lunch Kitchens and Serving Lines. Marketing Research Report No. 753.

Freshwater, J. F. 1967. Employee Productivity in Commercial Cafeterias. Paper presented at National Restaurant Association Convention. (Processed)

AREA NO. 1 PLANNING MARKETING FACILITIES

Line Project Check List -- Reporting Year July 1, 1966 to June 30, 1967

Work and Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Proj. Summary of Progress	Incl. in Area and Subheading
TF 1	Improving marketing facilities for farm and food products.			
TF 1-14 (Rev.)	Plan and promote the development of improved fresh fruit and vegetable wholesale marketing facilities in production areas.	Hyattsville, Md.	Yes	1-B-11 1-G-4
TF 1-15 (Rev.)	Plan and promote the development of improved poultry and egg wholesale marketing facilities in production areas.	Hyattsville, Md.	Yes	1-B-11 1-G-1
TF 1-16 (Rev.)	Plan and promote the development of improved livestock and meat wholesale marketing facilities in production areas.	Hyattsville, Md.	Yes	1-G-2
TF 1-18 <sup>1/</sup>	Plan and promote improved wholesale food marketing facilities and methods in Chicago, Ill.	Hyattsville, Md.	Yes	1-B-3
TF 1-21	Plan and promote the development of improved dairy and dairy food products wholesale marketing facilities in production areas.	Hyattsville, Md.	Yes	1-G-5
TF 1-22 <sup>1/</sup>	Plan and promote improved wholesale food marketing facilities and methods in Baltimore, Md.	Baltimore, Md. Hyattsville, Md.	Yes	1-A-1 1-B-1
TF 1-23	Plan and promote the development of more efficient methods, equipment, and facilities for wholesale food warehouses and processing operations.	Hyattsville, Md.	Yes	1-B-12 1-G-3
TF 1-24	Plan and promote the development of improved technical facilities for refrigerated food products.	Hyattsville, Md.	Yes	1-B-2-4 1-C
TF 1-26	Preliminary and followup work in the development of improved marketing facilities in specific locations.	Hyattsville, Md.	Yes	1-B-1-12 1-C 1-D 1-E 1-F
TF 1-27(C)	Development of criteria for planning food distribution facilities.	Hyattsville, Md.	Yes	1-C
TF 1-28	Plan and promote improved wholesale food marketing facilities and methods in Dayton, Ohio.	Hyattsville, Md.	Yes	1-A-2
TF 1-30	Plan and promote improved wholesale food marketing facilities and methods in Honolulu, Hawaii.	Honolulu, Hawaii	Yes	1-A-3
TF 1-31 <sup>2/</sup>	Plan and promote improved wholesale food marketing facilities and methods in Cincinnati, Ohio.	Hyattsville, Md. Cincinnati, Ohio	Yes	1-A-4
TF 1-32 <sup>3/</sup>	Plan and promote improved wholesale food marketing facilities and methods in Salt Lake City, Utah.	Hyattsville, Md. Salt Lake City, Utah	Yes	1-A-5 1-B-12
TF 1-33 <sup>4/</sup>	Plan and promote improved wholesale food marketing facilities and methods in Oakland, California.	Hyattsville, Md. Oakland, Calif.	Yes	1-A-6
TF 1-34 <sup>5/</sup>	Plan and promote improved wholesale food marketing facilities and methods in Denver, Colorado.	Hyattsville, Md. Denver, Colo.	Yes	1-B-12 1-A-7
TF 1-35(C) 6/	Determination of possible annual volume of product handled in specific situations.	Hyattsville, Md.	Yes	1-B-12 1-D

1/ Terminated February 1967.

2/ Initiated March 1967.

3/ Initiated May 1967.

4/ Initiated April 1967.

5/ Initiated April 1967.

6/ Initiated March 1967.

AREA 2 - DAIRY PRODUCTS

Line Project Check List - Reporting Year - July 1, 1966 to June 30, 1967

Work and Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Proj. Summary of Progress	Incl. in Area and Sub- heading
TF 2	:Improved Work Methods, Devices, Equipment, and : Related Facilities for the Off-Farm Condition- : ing, Handling, Storage, Preparation for Market, : and Marketing of Agricultural Products : Program Leadership	: Hyattsville, Md.	:	:
TF 2-31 (Rev.)	:Improved Layouts and Operating Criteria for Auto- : mated Dairy Plants	: Hyattsville, Md.	: Yes	: 2-A
TF 2-84	:Increasing Efficiency Through Optimum Utilization : of Automation in Multipurpose Fluid Milk Plants	: Columbia, Mo.	: Yes	: 2-B

AREA 3 - FIELD CROPS

Line Project Check List - Reporting Year July 1, 1966 to June 30, 1967

Work and Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Proj. Summary of Progress	Incl. in Area and Sub- heading
TF 2	Improved Work Methods, Devices, Equipment, and Related Facilities for the Off-Farm Conditioning, Handling, Storage, Preparation for Market, and Marketing of Agricultural Products.			
TF 2-2	Program Leadership	Hyattsville, Md.		
TF 2-2 (Rev. 2)	Testing and Evaluation of Crossflow, Counterflow, and Concurrent Flow Methods and Equipment for Continuous Grain Drying	Lafayette, Ind.	Yes	3-C-2
TF 2-32 (Rev. C)	Developing Improved Methods of Drying Field Shelled Corn for the Commercial Market	Lafayette, Ind.	No	
TF 2-33 (Rev.)	Handling Farmers Stock Peanuts at Commercial Storages	Albany, Ga.	Yes	3-B-2
TF 2-34 (Rev.)	Conditioning and Storing Farmers Stock and Shelled Peanuts at Commercial Storages	Albany, Ga.	Yes	3-B-3
TF 2-44 (Rev.)	Improved Duct Designs for Grain Aeration Systems in Commercial Storages	Hyattsville, Md.	No	
TF 2-52 (Rev.)	Aerating, Conditioning, and Handling CCC Stored Grain	Hyattsville, Md.	No	
TF 2-57 (Rev.)	Handling and Storage of Bales of Cotton	Bakersfield, Cal.	Yes	3-F-1
TF 2-66	Cleaning and Shelling Farmers Stock Peanuts and Grading Shelled Peanuts	Albany, Ga.	Yes	3-B-1
TF 2-70 (CA)	Handling, Drying, Aerating, and Storing Cottonseed in Commercial Storages	Stoneville, Miss.	Yes	3-G
TF 2-74	Conditioning Moist Grain in Upright Commercial Storages in the Hard Winter Wheat Area	Manhattan, Kans.	Yes	3-C-1
TF 2-76	Development of Satisfactory Equipment and Methods for Humidifying Cotton Storage Compartments to Maintain the Moisture Content of Stored Bales at Desirable Levels	Bakersfield, Cal.	Yes	3-F-2
TF 2-83	Handling Tobacco in Warehouses (Sales Floors) and Redrying Plants	Raleigh, N.C.	Yes	3-H-1
TF 2-87 (C)	Measurement of Physical Damage to Grain by Equipment Used in Handling Grain	Hyattsville, Md.	Yes	3-D-1
TF 2-88 (CA)	Design Principles and Operating Methods for Handling Equipment that Affect Physical Damage to Grain	Manhattan, Kans.	Yes	3-D-1
TF 2-91	Improved Design and Operation of Aeration Systems in Commercial Storages in the Central Plains Area	Manhattan, Kans.	Yes	3-C-1
TF 2-92 (C)	Improved Methods, Techniques, and Equipment for the Drying and Storing of Rice at Commercial Dryers, Warehouses, and Mills	Beaumont, Tex.	Yes	3-A-1, 2
TF 2-93	Improved Methods, Techniques and Equipment for Handling Rough and Milled Rice at Commercial Facilities	Beaumont, Tex.	Yes	3-A-3, 4
TF 2-94 (CA)	Storage Conditions Necessary to Maintain the Market Quality of Unprocessed Flue-Cured Tobacco	Raleigh, N. C.	Yes	3-H-2
TF 2-95 (CA)	Laboratory Investigations of the Angle of Repose and Coefficient of Friction of Farmers Stock Peanuts During Bulk Handling and Storage Operations	Tuskegee, Ala.	Yes	3-B-2
TF 2-96 (CA)	Improved Techniques and Equipment for Uniformly Blending Heterogeneous Lots of Seed	State College, Miss.	Yes	3-I
TF 2-97 (C)	Basic Theory of Static and Dynamic Pressure Phenomena in Grain in Storage Structures	St. Louis, Mo.	Yes	3-E
TF 2-103	More Effective Schedules for Turning and Other Grain Handling Operations in Commercial Storages in the Central Plains Area	Manhattan, Kans.	Yes	3-C-1
TF 2-104 (CA) 4/	Grain Drying and Storage Practices and Their Relation to Mycotoxin Development and Grain Quality	Lafayette, Ind.	Yes	3-C-2

1/ Terminated July 1966 and superseded by TF 2-104(CA).

2/ Terminated July 1966.

3/ Revised Oct. 1966.

4/ Initiated Sept. 1966.

AREA 4 - HORTICULTURAL CROPS

Line Project Check List - Reporting Year July 1, 1966 to June 30, 1967

Work and Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Proj. Summary of Progress	Incl. in Area and Sub- heading
TF 2	Improved Work Methods, Devices, Equipment, and Related Facilities for the Off-Farm Conditioning, Handling, Storage, Preparation for Market, and Marketing of Agricultural Products.	Program Leadership	Hyattsville, Md.	
TF 2-30 (Rev.2)	Improved Pallet Boxes and Auxiliary Equipment for Handling and Storage of Fruits and Vegetables	Michigan	Yes	4-J-1
TF 2-36 (Rev.)	Measuring Cooling Rates of Apples	Wenatchee, Wash.	Yes	4-E-1
TF 2-37 (Rev.)	Methods, Equipment, and Facilities for the Storage of Apples and Other Tree Fruits	Wenatchee, Wash.	Yes	4-E-2
TF 2-38 (Rev.)	Controlled-Atmosphere Storage of Apples in the Pacific Northwest	Wenatchee, Wash.	Yes	4-E-3
TF 2-53 (Rev.)	Handling and Preparation for Market of Fall-Crop Potatoes	East Grand Forks, Minn.	Yes	4-C-3
TF 2-54 (Rev.)	Cleaning and Sizing Fall-Crop Potatoes Before Storage	East Grand Forks, Minn.	Yes	4-C-3
TF 2-55 (Rev.)	Designs for Potato Storage and Packinghouses	East Grand Forks, Minn.	Yes	4-F-1
TF 2-60	Providing Optimum Conditions for the Storage of Potatoes for Processing	East Grand Forks, Minn.	Yes	4-F-2
TF 2-61	Degreening and Precooling Citrus Fruits	Gainesville, Fla.	Yes	4-A,H
TF 2-62(C)	Presorting and Presizing Apples	East Lansing, Mich.	Yes	4-B-2
TF 2-63	Handling Citrus Fruits in Pallet Boxes	Gainesville, Fla.	Yes	4-A
TF 2-64	Methods, Equipment and Operating Procedures for the Preparation for Market of Citrus Fruits	Gainesville, Fla.	Yes	4-A
TF 2-65	Handling and Preparation for Market of Vegetables	Gainesville, Fla.	Yes	4-D
TF 2-67	Handling and Curing Sweetpotatoes	Raleigh, N. C.	Yes	4-J-2
TF 2-68	Impact of Color Sorting of Apples	Wenatchee, Wash.	Yes	4-B-1
TF 2-69	Presorting and Presizing Apples in Commercial Storages and Packinghouses	Wenatchee, Wash.	Yes	4-B-1
TF 2-79	Handling and Preparation for Market of Peaches	Athens, Ga.	Yes	4-B-3
TF 2-80 (CA)	Preparing Maine Potatoes for Market	Presque Isle and Orono, Maine	Yes	4-C-1
TF 2-81	Handling Maine Potatoes	Presque Isle, Maine	Yes	4-C-1
TF 2-82	Preparing Spring Crop Potatoes for Market	Gainesville, Fla.	Yes	4-C-2
TF 2-90	Handling and Preparing Pecans for Market	Athens, Ga.	Yes	4-K
TF 2-98 (CA)	Air Precooling of Fruits and Vegetables	Athens, Ga.	Yes	4-G
TF 2-99 1/	Heat Transfer Characteristics of Fruit and Vegetables	Athens, Ga.	Yes	4-G, H,I
TF 2-100 2/	Precooling Systems of Fruit and Vegetable Packinghouses	Athens, Ga.	Yes	4-G
TF 2-106 (CA) 3/	Hydraulic Handling System for Potatoes, Sugar Beets, and Other Crops	Presque Isle and Orono, Maine	Yes	4-C-1
TF 2-107 4/	Heat Transfer Characteristics During Forced Air Precooling of Fresh Florida Vegetables	Gainesville, Fla.	Yes	4-I

1/ Approved, May 1967.

2/ Approved, November 1966.

3/ Approved, September 1966.

4/ Approved, May 1967.

AREA 5 - LIVESTOCK, MEAT AND WOOL

Line Project Check List - Reporting Year - July 1, 1966 to June 30, 1967

Work and Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Proj. Summary of Progress	Incl. in Area and Sub- heading
TF 2	: Improved Work Methods, Devices, Equipment, and : Related Facilities for the Off-Farm Conditioning: : Handling, Storage, Preparation for Market, and : Marketing of Agricultural Products : Program Leadership	: : Hyattsville, Md.	: :	:
TF 2-24 (Rev. 2)	: Improved Work Methods and Facilities for Frozen Meat Portion Control Hotel Supply Houses	: : Stillwater, Okla.	Yes	5-E
TF 2-42 (Rev.)	: Automation of Sales and Yarding Operations on Livestock Markets	: : Columbia, Mo.	Yes	5-A
TF 2-58 <u>1/</u>	: Improved Work Methods, Equipment, and Facilities for Hog Slaughtering Plants	: : Stillwater, Okla.	Yes	5-D
TF 2-71 (Rev.) (CA) <u>2/</u>	: Work Methods, Equipment and Facilities for Handling and Processing "Hot" Pork Products	: : Stillwater, Okla.	Yes	5-G
TF 2-85	: Improved Work Methods, Equipment, and Facilities for Beef and Veal Boning Lines	: : Stillwater, Okla.	Yes	5-H
TF 2-86	: More Efficient Work Methods, Equipment, and Facilities for Small Meat By-Product Rendering Plants	: : Stillwater, Okla.	Yes	5-F
TF 2-101 (CA)	: Improved Methods and Equipment for Handling Sales Data on Livestock Markets	: : Columbia, Mo.	Yes	5-B
TF 2-102	: Improved Work Methods, Equipment, and Facilities for Smoked and Cured Specialty Meat Processing Plants	: : Stillwater, Okla.	Yes	5-I
TF 2-105 <u>3/</u>	: Improved Layouts, Equipment and Operating Criteria: for Livestock Auction Markets	: : Columbia, Mo.	Yes	5-C

1/ Terminated October 1966.

2/ Revised December 1966.

3/ Initiated November 1966.

AREA 6 - POULTRY AND EGGS

Line Project Check List - Reporting Year July 1, 1966 to June 30, 1967

Work and Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Proj. Summary of Progress	Incl. in Area and Sub- heading
TF-2	Improved Work Methods, Devices, Equipment, and Related Facilities for the Off-Farm Conditioning, Handling, Storage, Preparation for Market, and Marketing of Agricultural Products. Program Leadership	Hyattsville, Md.		
TF 2-17 (Rev.) <sup>1/</sup>	Improved Work Methods and Equipment for Grading and Packing Shell Eggs in Commercial Plants	Hyattsville, Md.	Yes	6-A
TF 2-41 <sup>2/</sup> (Rev.)	Improved Methods, Techniques, and Equipment for Cleaning Eggs	Davis, Calif.	Yes	6-B
TF 2-49 (Rev.)	Improved Work Methods and Equipment for Cutting Up and Packing Chickens in Processing Plants	Athens, Ga.	Yes	6-E
TF 2-50 (Rev.)	Improved Layouts and Designs for Poultry Processing Plants	Athens, Ga.	No	6-F
TF 2-72	Improved Methods, Equipment and Facilities for Chilling, Weighing, and Packing Turkeys in Processing Plants	Davis, Calif.	Yes	6-I
TF 2-73	Improved Layouts and Engineering Designs for Egg Grading and Packing Plants	Davis, Calif.	Yes	6-C
TF 2-75(C)	Improved Methods, Equipment and Facilities for Cutting Up, Deboning and Preparing Turkey Specialty Items	Davis, Calif.	Yes	6-J
TF 2-77	Methods, Equipment and Facilities for Improving Plant Efficiency through Balanced Inspection and Evisceration Operations in Chicken Processing Plants	Athens, Ga.	Yes	6-G
TF 2-78	Improved Methods and Equipment for Handling Live Chickens by Commercial Processing Plants	Athens, Ga.	Yes	6-H
TF 2-89 (CA)	Development of Equipment and Methods for Pasteurizing Liquid Whole Eggs in Small Volume Egg Breaking Rooms	Davis, Calif.	Yes	6-D

1/ Discontinued January 18, 1966

2/ Discontinued July 1, 1966

AREA 7 - CONSUMER PACKAGES AND SHIPPING CONTAINERS

Line Project Check List -- Reporting Year July 1, 1966, to June 30, 1967

Work and Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Project Incl. in Summary of Progress	in Area and Subheading
TF 4	: Improved Transportation, Facilities, Equipment and Methods, and Improved Shipping	: Work Locations During Past Year	: Summary of Progress	: Area and Subheading
TF 4-3 (Rev.) <u>1/</u>	: Container and Packaging for Agricultural Commodities	: Hyattsville, Md.	: Yes	: 7-A-9
TF 4-19 (Rev.) <u>2/</u>	: Prepackaging Fresh Fruits and Vegetables at the Terminal Market Level	: Hyattsville, Md.	: Yes	: 7-B-2
TF 4-29 <u>3/</u>	: Development and Evaluation of large Containers for Fluid Milk Consumed in the Home	: Yakima, Washington	: Yes	: 7-A-8
TF 4-54	: Development and Evaluation of Improved Shipping Containers for Fresh Western Pears, Plums, Peaches, Nectarines and Apricots	: Yakima, Washington	: Yes	: 7-A-2,-3
TF 4-55	: Standardization and Simplification of Containers for Fresh Fruits and Vegetables	: Hyattsville, Md.	: Yes	: 7-A-11
TF 4-56	: Development and Evaluation of Improved Packages and Shipping Containers for Cut Flowers and Potted Plants	: Fresno, Calif.	: Yes	: 7-A-12
TF 4-58	: Development and Evaluation of Shipping Containers and Packages for Overseas Movement of Fresh Fruits and Vegetables to European Markets	: Orlando, Fla.	: Yes	: 7-C-1
TF 4-59	: Development and Evaluation of Improved Shipping Containers and Packages for Poultry Shipped to Overseas Markets	: Hyattsville, Md.	: Yes	: 7-C-2
TF 4-63 <u>4/</u>	: Development and Evaluation of Expanded Polystyrene Foam Shipping Containers for Fresh Ice-Packed Poultry	: Hyattsville, Md.	: Yes	: 7-B-1
TF 4-64 <u>5/</u>	: Development and Evaluation of New Shipping Containers for Fresh Temple Oranges	: Orlando, Fla.	: Yes	: 7-A-5

1/ Terminated April 1966

4/ Initiated February 1967

Continued

2/ Terminated August 1967

5/ Initiated February 1967

3/ Terminated December 1965

AREA 7 - CONSUMER PACKAGES AND SHIPPING CONTAINERS (continued)

Line Project Check List -- Reporting Year July 1, 1966, to June 30, 1967

Work and Line Project Number	Line	Project	Incl.	
TF 4-65 (c)	:	:	:	
	Work and Line Project Titles	Work Locations	Summary of Area and Progress	
		During Past Year	Subheading	
	Prepackaging Jumble-Packed	Hyattsville, Md.	Yes	7-A-7
	Fresh Bartlett Pears, Plums,	:	:	:
	and Nectarines in Terminal	:	:	:
	Prepackaging Plants	:	:	:
	:	:	:	:
Research Activity <sup>6</sup> 1-13-503-15-001	Development and Evaluation of	Yakima, Wash.	Yes	7-A-1
	Improved Shipping Containers	:	:	:
	for Apples	:	:	:
	:	:	:	:
Research Activity <sup>6</sup> 1-13-503-15-001	Development and Evaluation of	Fresno, Calif.	Yes	7-A-4
	Improved Shipping Containers	Hyattsville, Md.	:	:
	for Grapes	:	:	:
	:	:	:	:
Research Activity <sup>7</sup> 1-12-503-15-006	Development and Evaluation of	:	:	:
	Packages and Shipping Containers	Orlando, Fla.	Yes	7-A-6
	for Partially Prepared Citrus	:	:	:
	:	:	:	:
Research Activity <sup>8</sup> 1-12-503-15-008	Development and Evaluation of	Hyattsville, Md.	Yes	7-A-10
	Improved Shipping Containers	:	:	:
	and Packaging Materials for	:	:	:
	Tomato Transplants	:	:	:

6/ Improved shipping containers--jumble filled fiberboard boxes and pallet bin boxes for fresh apples, grapes, pears, plums, prunes, peaches, nectarines and apricots marketed in the United States.

7/ Improved packages and shipping containers for thin-skinned citrus fruits in the United States.

8/ Improved shipping containers--wirebound crates and fiberboard boxes with various types of liners for tomato transplants.

AREA 8 - TRANSPORT EQUIPMENT AND TECHNIQUES

Line Project Check List -- Reporting Year July 1, 1966 to June 30, 1967

Work and Line Project Number	:	Work and Line Project Titles	:	Work Locations	Summary of : During Past Year	Area and Progress	Line Project Incl. in Subheading
TF 4	:	Improved Transportation Facilities, Equipment, and Methods, and Improved Shipping Containers and Packaging for: Agricultural Commodities	:	:	:	:	:
TF 4-6 (Rev.)	:	Pallet Containers for Transportation	:	Hyattsville, Md.	Yes		8-B-4
TF 4-24 (Rev.)	<u>1/</u>	Air Circulation and Refrigerated Trailers	:	Hyattsville, Md.	No		--
TF 4-26	<u>2/</u>	Improved Loading of Watermelons	:	Hyattsville, Md.	Yes		8-B-5
TF 4-42	<u>3/</u>	Improved Loading of Onions	:	Hyattsville, Md.	Yes		8-B-3
TF 4-52 (C)	:	Unitized and Palletized Transport	:	Hyattsville, Md.	Yes		8-B-2
TF 4-53 (C-CA)	:	Multi-Purpose Transport Vehicles	:	Hyattsville, Md.	Yes		8-A-1
TF 4-60	:	Overseas Transport	:	Hyattsville, Md.	Yes		8-B-1
TF 4-61	:	Transport of Floral Products	:	Hyattsville, Md.	Yes		8-A-2
TF 4-62 (C)	:	Grain Transport of Boxcars	:	Hyattsville, Md.	Yes		8-A-3

1/ Discontinued September 19, 1966

2/ Discontinued May 4 1966

3/ Discontinued April 8 1966

AREA 9 RETAIL FOOD STORE OPERATIONS

Line Project Check List -- Reporting Year July 1, 1966 to June 30, 1967

Work and Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Project Incl. in	
			Summary of Progress (Yes-No)	Area and Subheading
TF 5 (Rev.)	Improved methods, operating practices, equipment, materials, and layout for wholesaling and retailing of farm and food products.			
TF 5-21 <u>1</u> /	Improved preparation and packaging of produce at the central warehouse.	Hyattsville, Md.	Yes	9-B-1
TF 5-22 <u>2</u> /	Systems and equipment for packaging and price-marking meat and poultry in retail food stores.	Hyattsville, Md.	Yes	9-A-1
TF 5-26 <u>3</u> /	Increased efficiency of small stores, superettes, and supermarkets through the adaptation of research results.	Hyattsville, Md.	Yes	9-D-1
TF 5-31 <u>4</u> /	Improved retail bakery department methods and practices.	Hyattsville, Md.	Yes	9-C-1
TF 5-36(CA)	Optimum work methods, equipment, layout, and store organization for the total retail food store.	Hyattsville, Md.	Yes	9-D-2
TF 5-38 (C)	The effect of improved techniques of sanitation and temperature control in retail handling of meat.	Hyattsville, Md.	Yes	9-A-3
TF 5-48 <u>5</u> /	Improved display and customer service for meat and poultry products in retail food stores.	Hyattsville, Md.	Yes	9-A-2
TF 5-49 <u>6</u> /	Increased efficiency of independently owned and operated small food distribution firms.	Hyattsville, Md.	Yes	9-D-1
TF 5-52(C) <u>7</u> /	Development of a low cost meat distribution system.	Hyattsville, Md.	Yes	9-E
TF 5-53 <u>8</u> /	Improved retail "bake-off" and "on-premise" bakery departments--methods and procedures.	Hyattsville, Md.	Yes	9-C-1

1/ Terminated 12/9/66.

2/ Terminated 5/19/66.

3/ Superseded by TF 5-49.

4/ Superseded by TF 5-53.

5/ Initiated 9/21/66.

6/ Initiated 9/21/66.

7/ Initiated 2/17/67.

8/ Initiated 4/27/67.

AREA 10.--WHOLESALE FOOD OPERATIONS

Line Project Check List -- Reporting Year July 1, 1966 to June 30, 1967

Work and Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Project Summary of Progress (Yes-No)	Incl. in Area and Subheading
TF 5 (Rev.)	Improved methods, operating practices, equipment, materials, and layout for wholesaling and retailing of farm and food products.			
TF 5-30 <u>1/</u>	Costs, margins, and operating ratios as determined through uniform accounting in wholesale food distribution businesses--cooperative with the Marketing Economics Division, ERS.	Hyattsville, Md.	Yes	10-C-1,2
TF 5-32 <u>2/</u>	Improved inventory control and space allocation for wholesale grocery warehouses.	Hyattsville, Md.	Yes	10-C-2
TF 5-39	Improved work methods, equipment and layout for handling frozen foods in wholesale warehouses.	Hyattsville, Md.	Yes	10-B-1
TF 5-47 <u>3/</u>	Improved methods, operating practices, equipment, materials, and layout for handling groceries from the manufacturers' warehouse through the retail store checkstand.	Hyattsville, Md.	Yes	10-A-1,2,3,4
TF 5-50 <u>4/</u>	Improved work methods, equipment and layout for handling foods in integrated warehouses.	Hyattsville, Md.	Yes	10-D-1 10-C-1,3

1/ Terminated 5/16/66.

2/ Terminated 1/23/67.

3/ Initiated 8/30/66.

4/ Initiated 11/10/66

AREA 11.--INSTITUTIONAL FOOD SERVICE OPERATIONS

Line Project Check List -- Reporting Year July 1, 1966 to June 30, 1967

Work and Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Project Incl. in	
			Summary of Progress (Yes-No)	Area and Subheading
TF 5 (Rev.)	Improved methods, operating practices, equipment, materials, and layout for wholesaling and retailing of farm and food products.			
TF 5-43 (C)	Improved methods, operational practices, equipment, materials, and layout for commercial cafeterias and serving lines.	Hyattsville, Md.	Yes	11-B-1,2
TF 5-46 1/	Improved methods, equipment and layout for grocery and complete line institutional wholesalers.	Hyattsville, Md.	Yes	11-A-1,2
TF 5-51 (C)	Improved efficiency for distributing food through food service outlets.	Hyattsville, Md.	Yes	11-B-3,4

1/ Initiated 8/30/66

2/ Initiated 11/10/66





